

FIG. 1

BEST AVAILABLE COPY

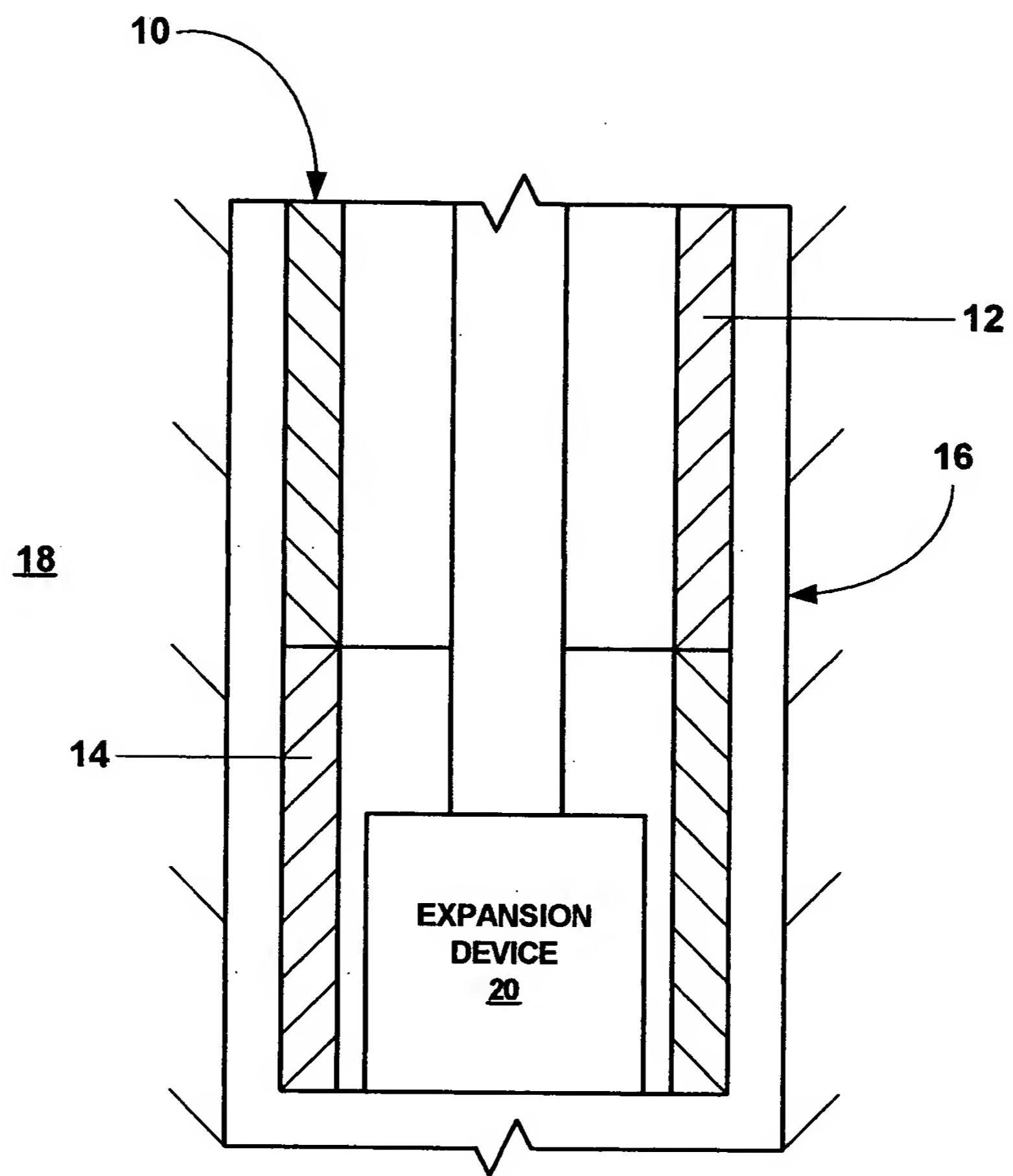


FIG. 2

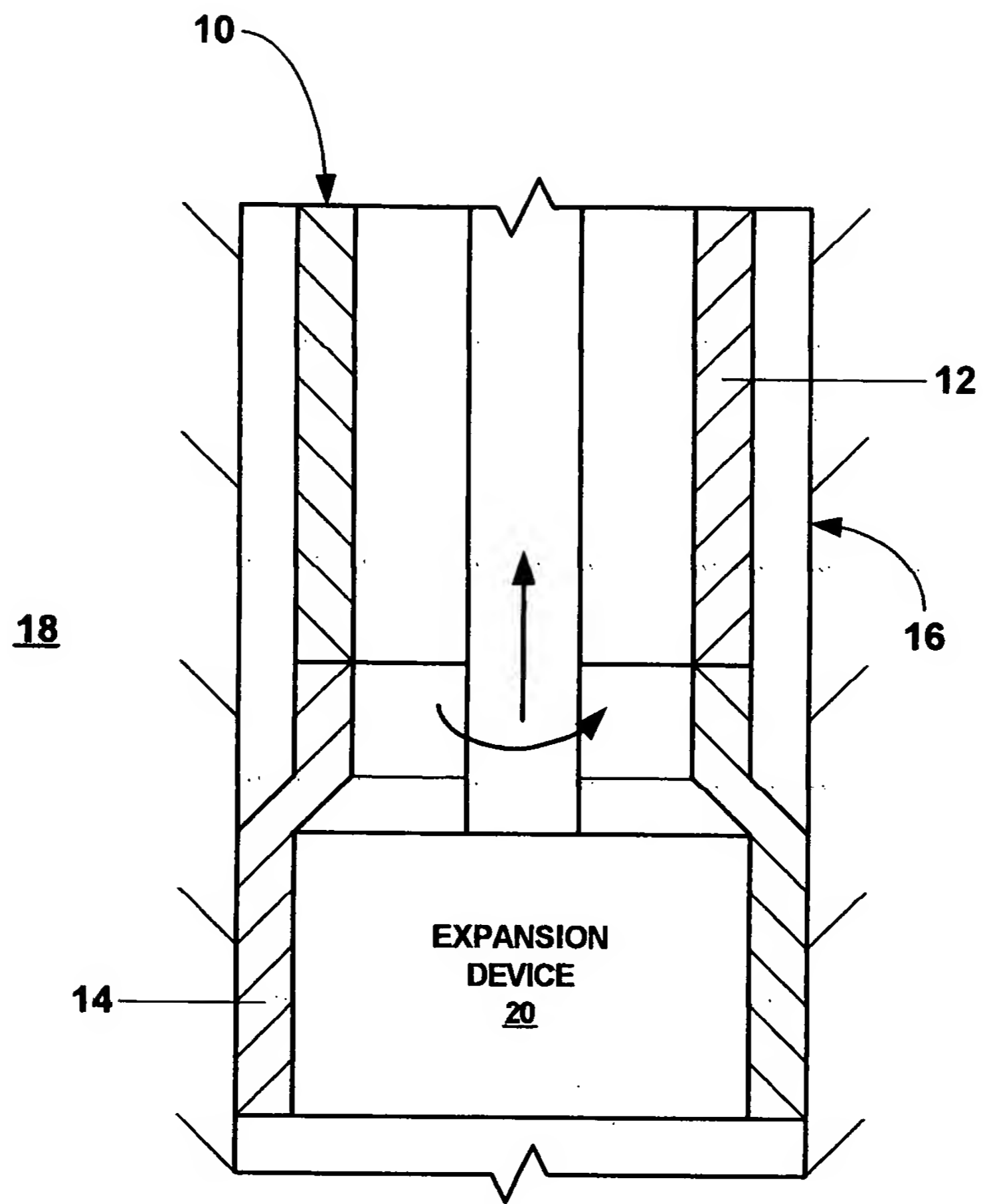


FIG. 3

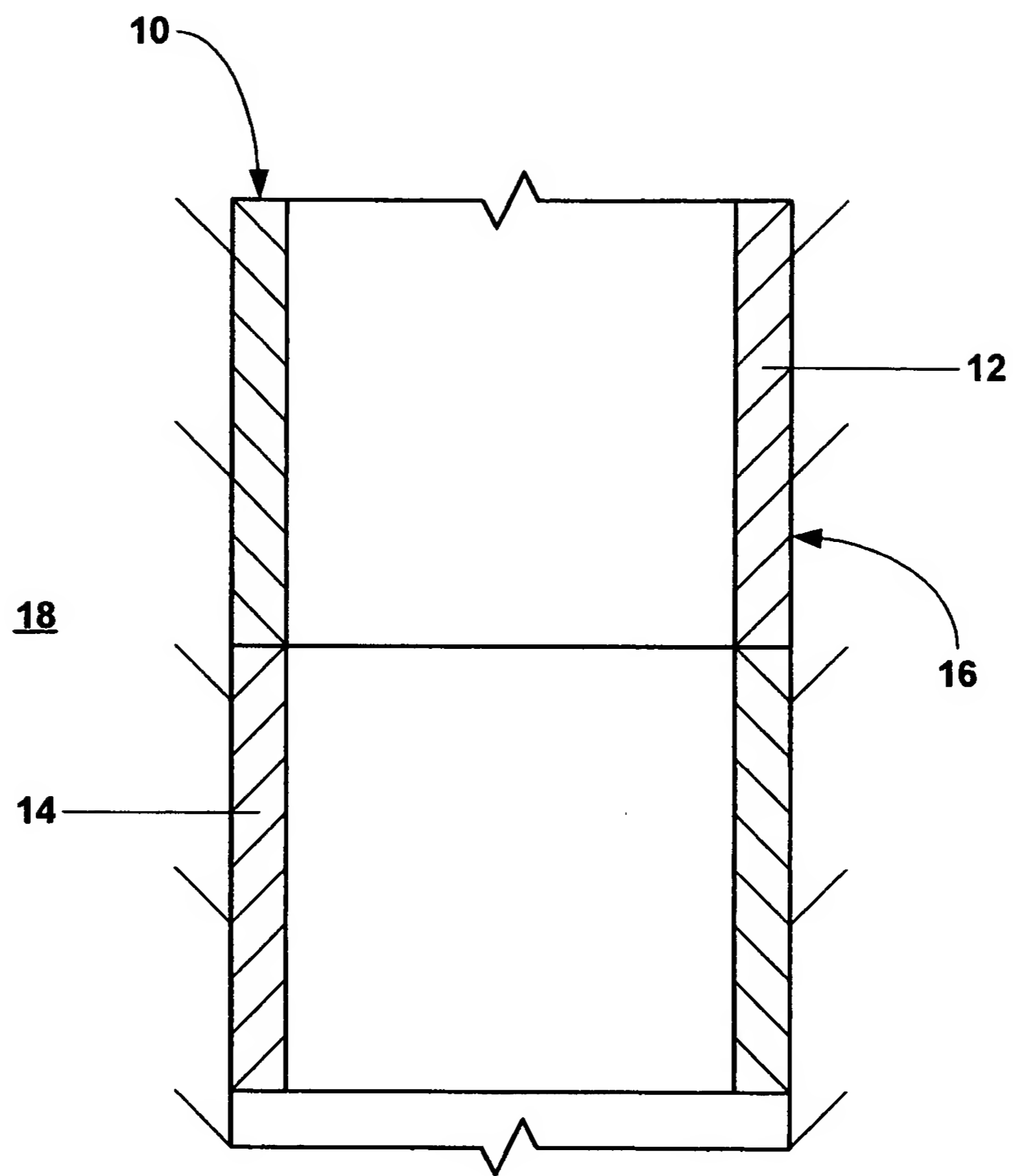


FIG. 4

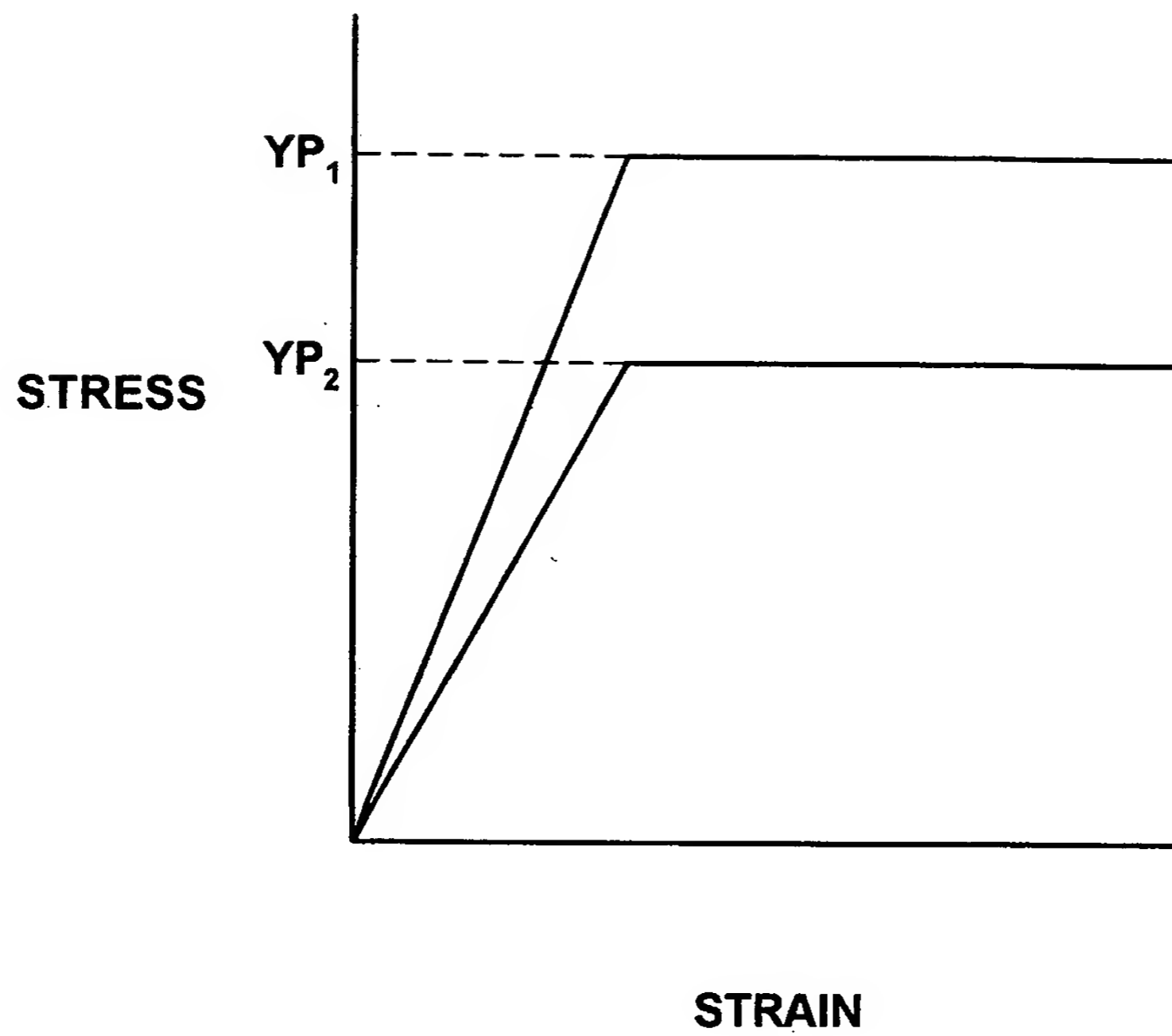


FIG. 5

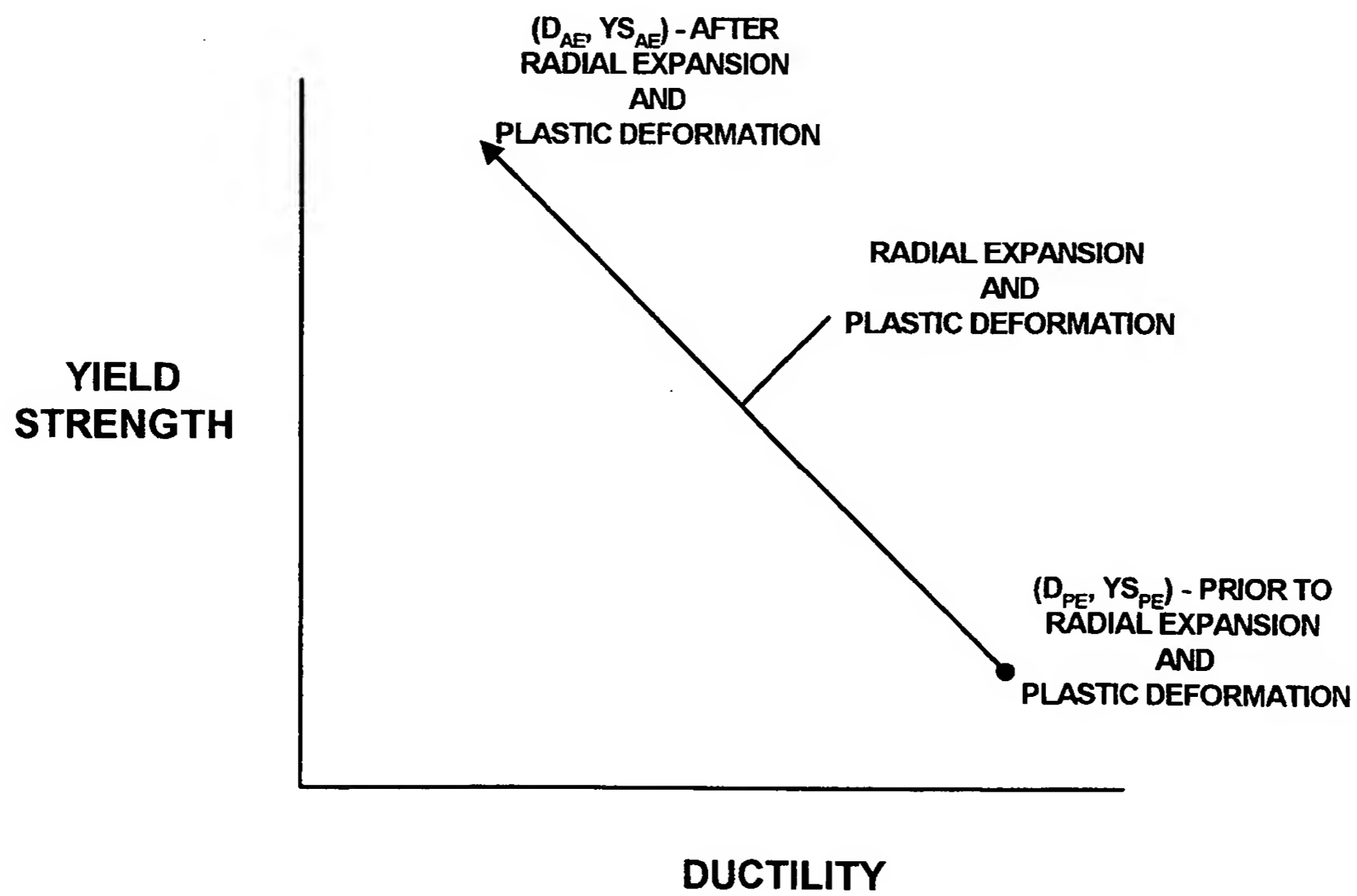


FIG. 6

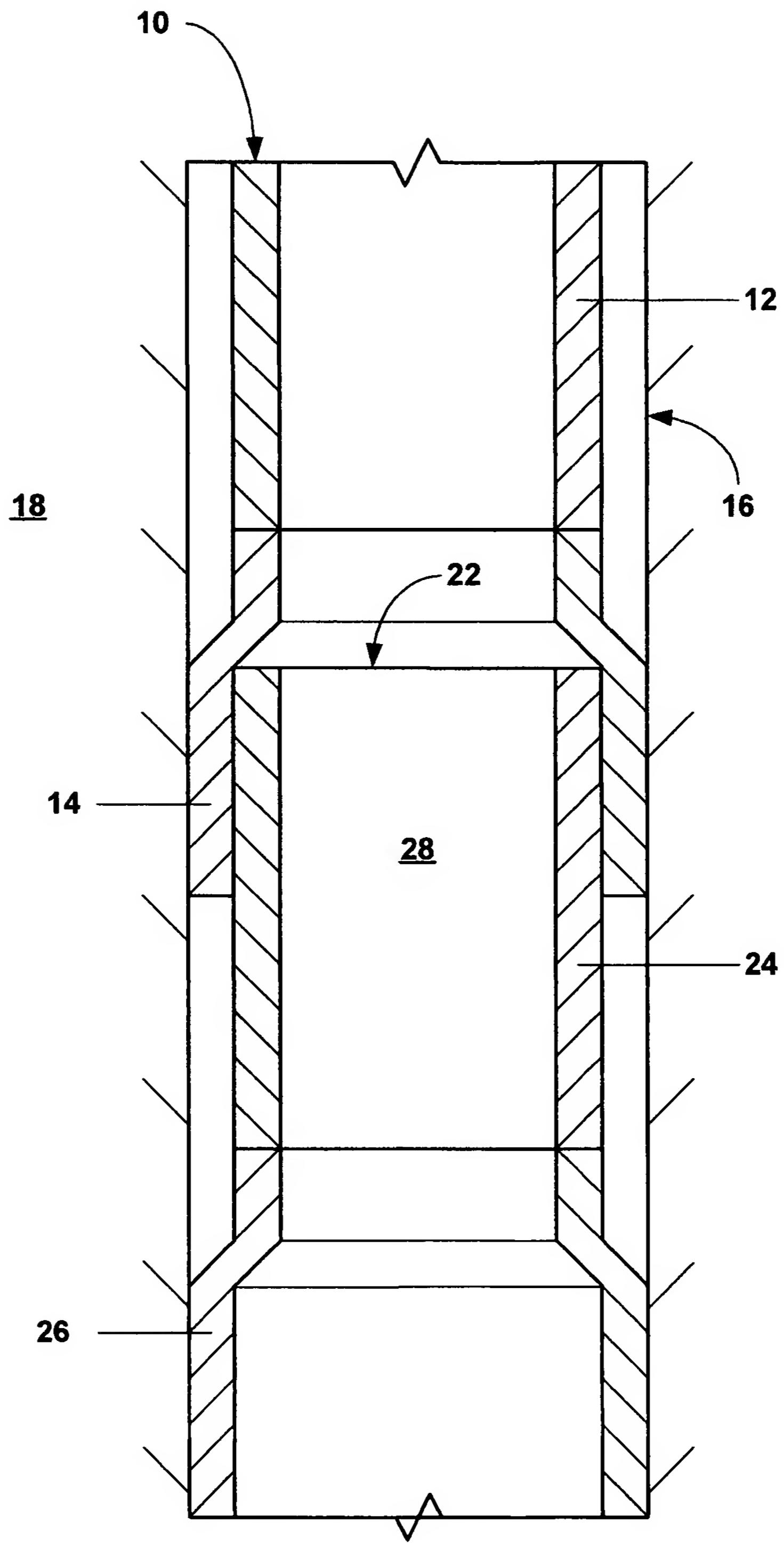


FIG. 7

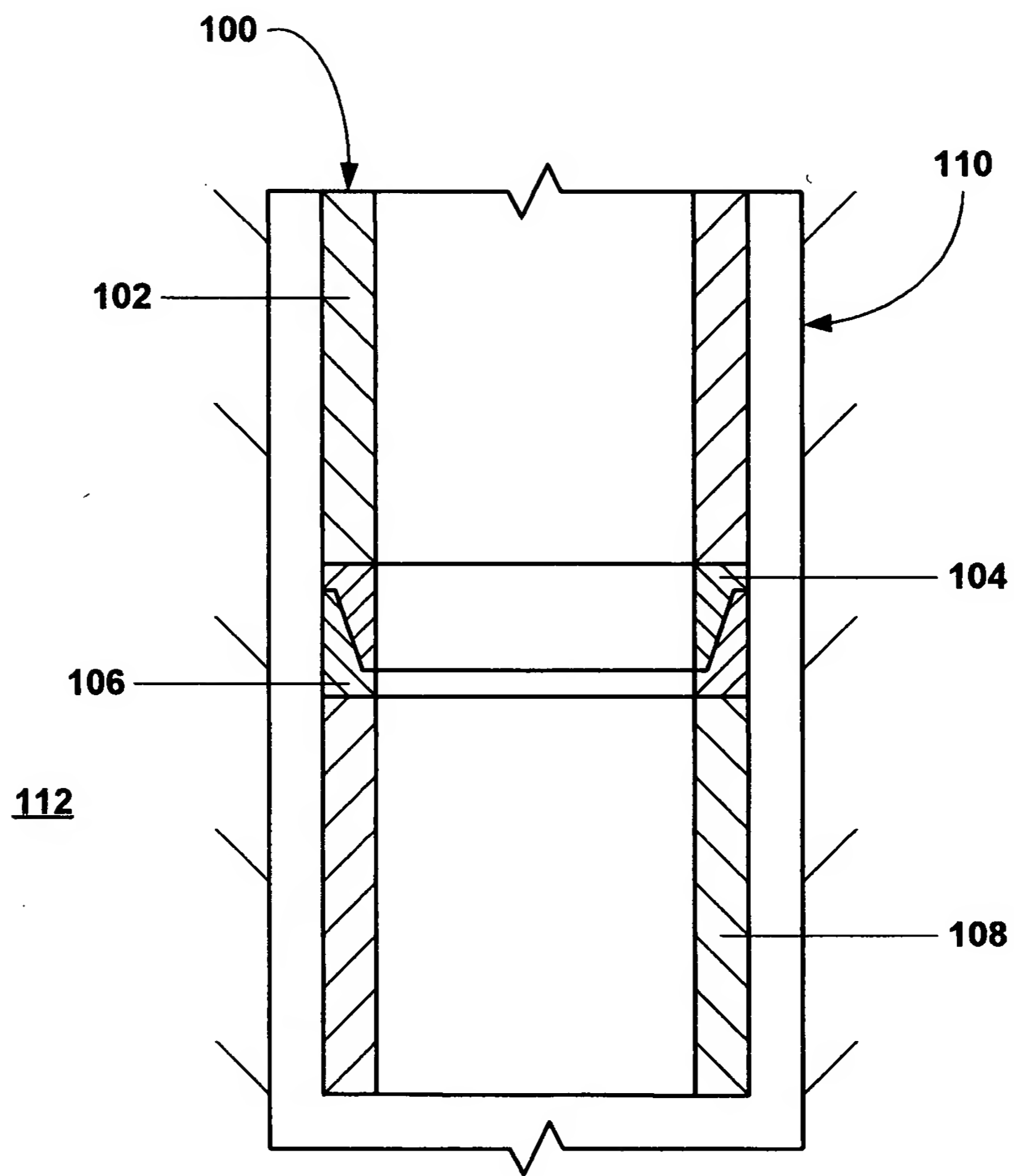


FIG. 8

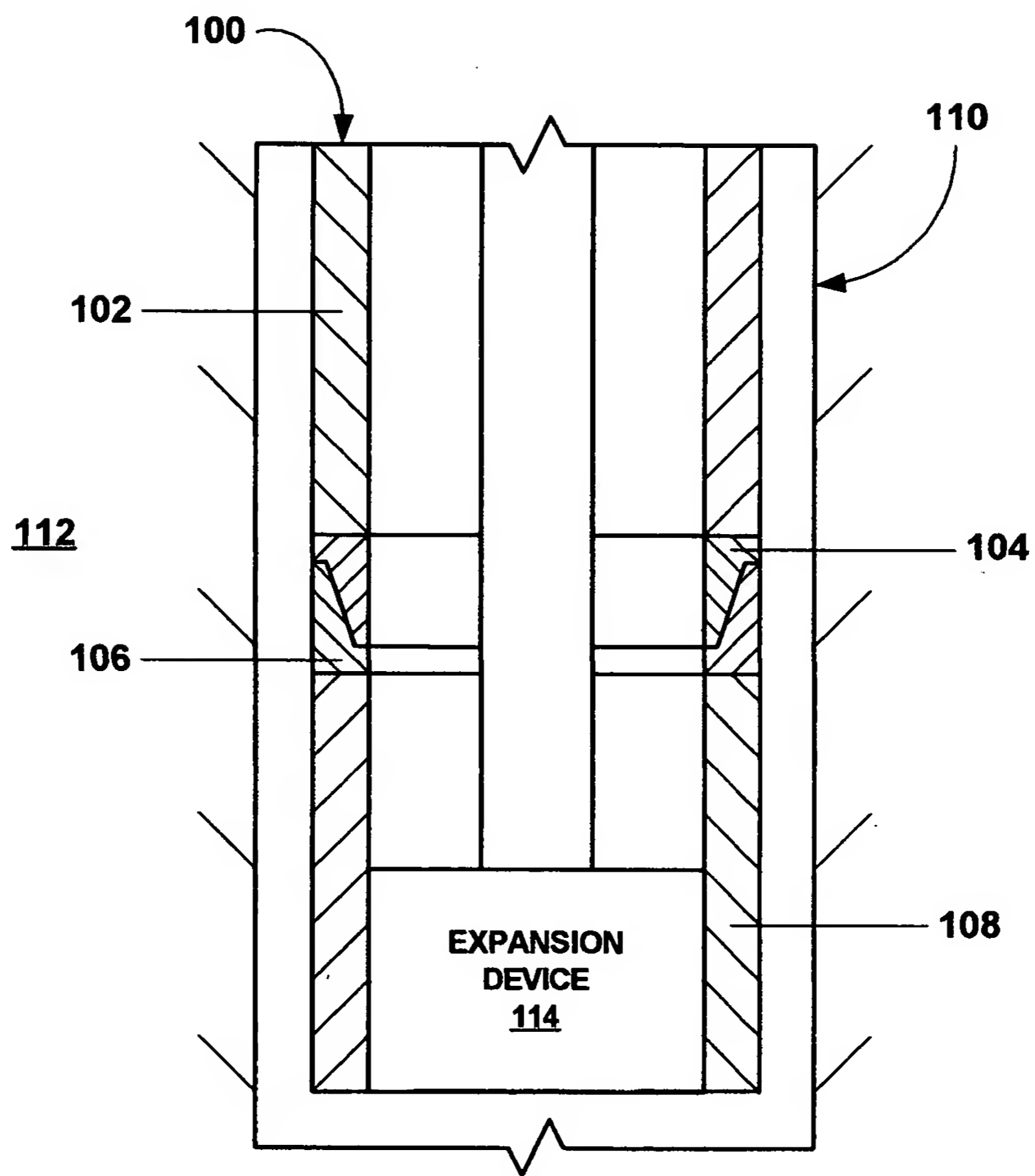


FIG. 9

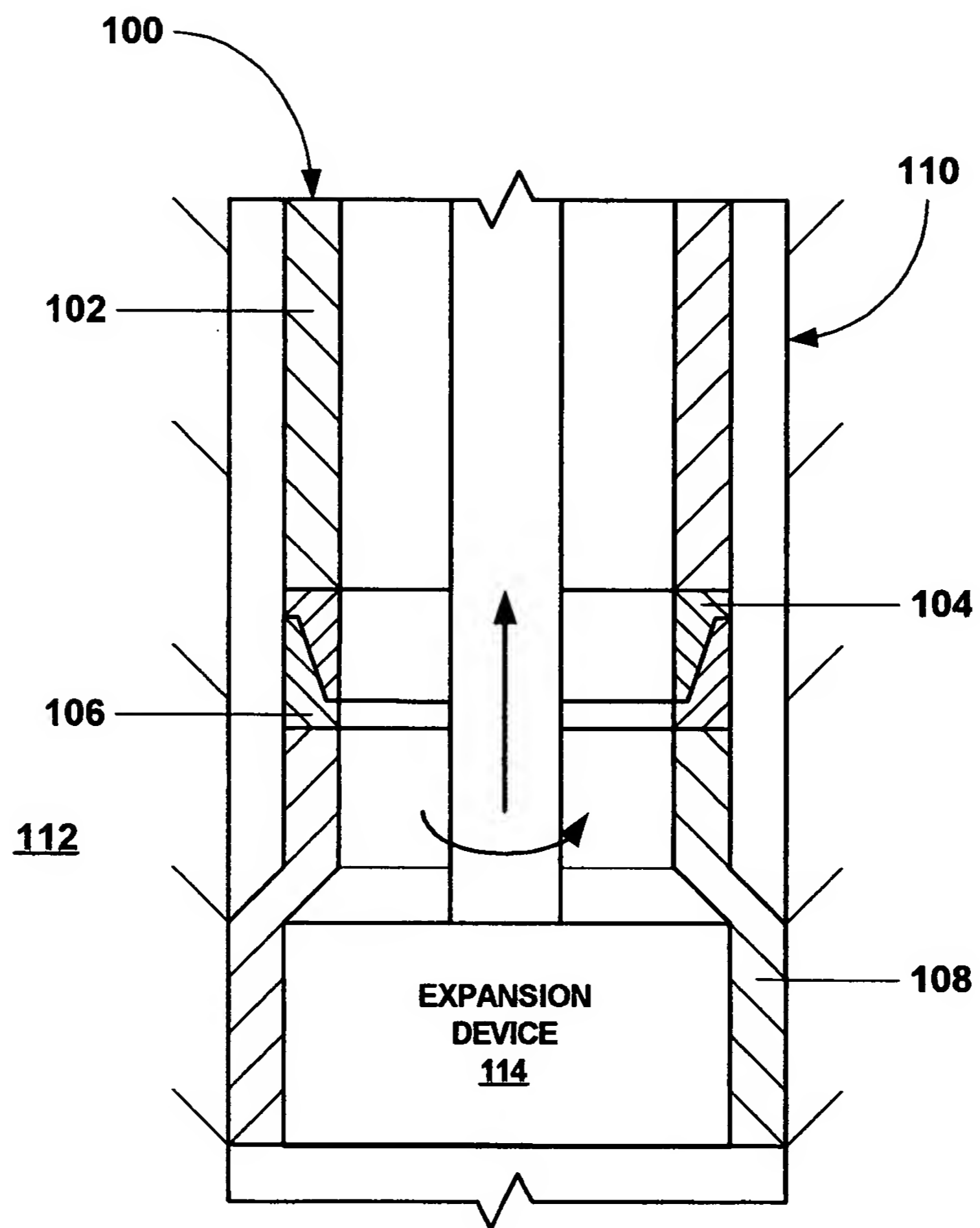


FIG. 10

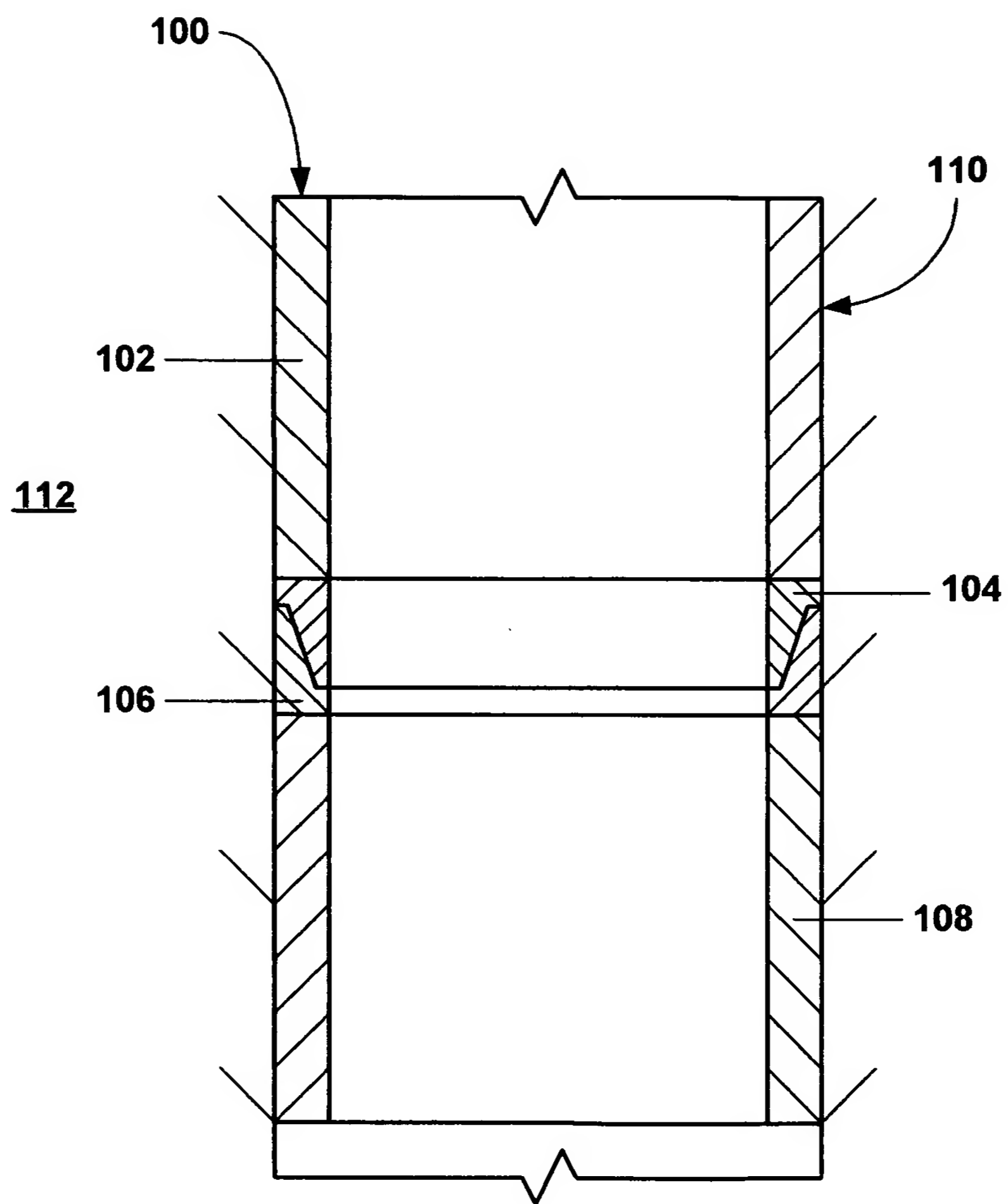


FIG. 11

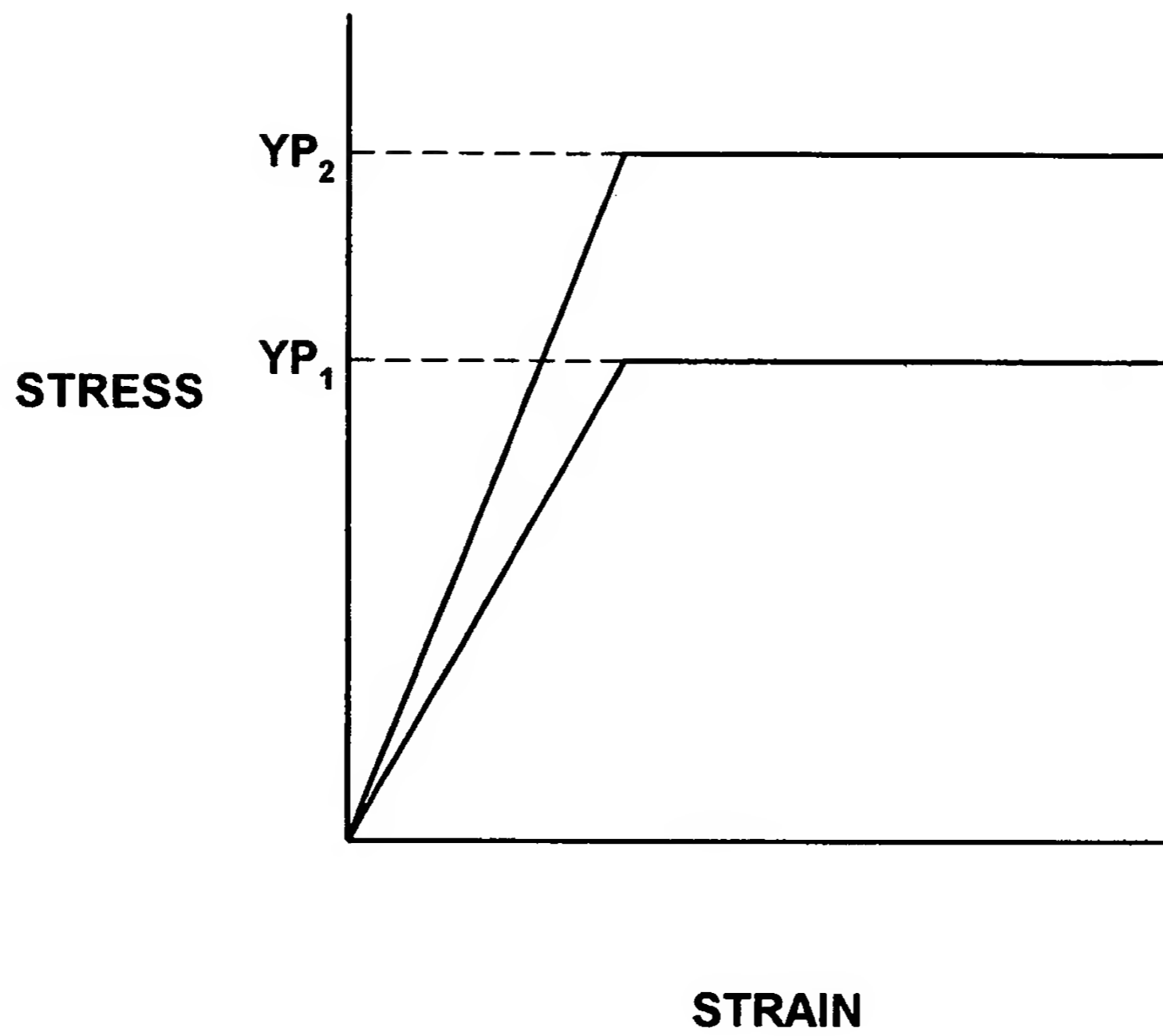


FIG. 12

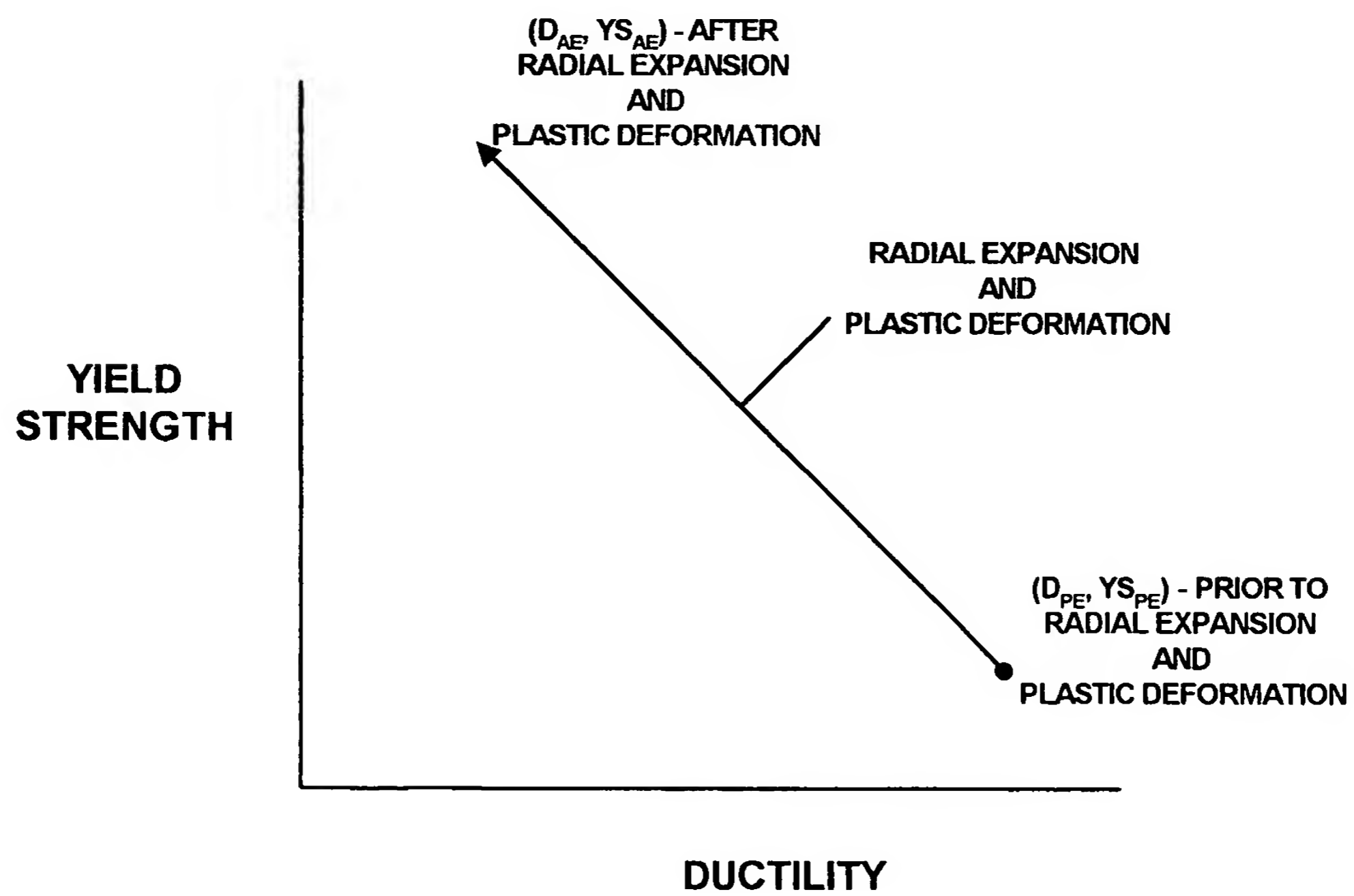


FIG. 13

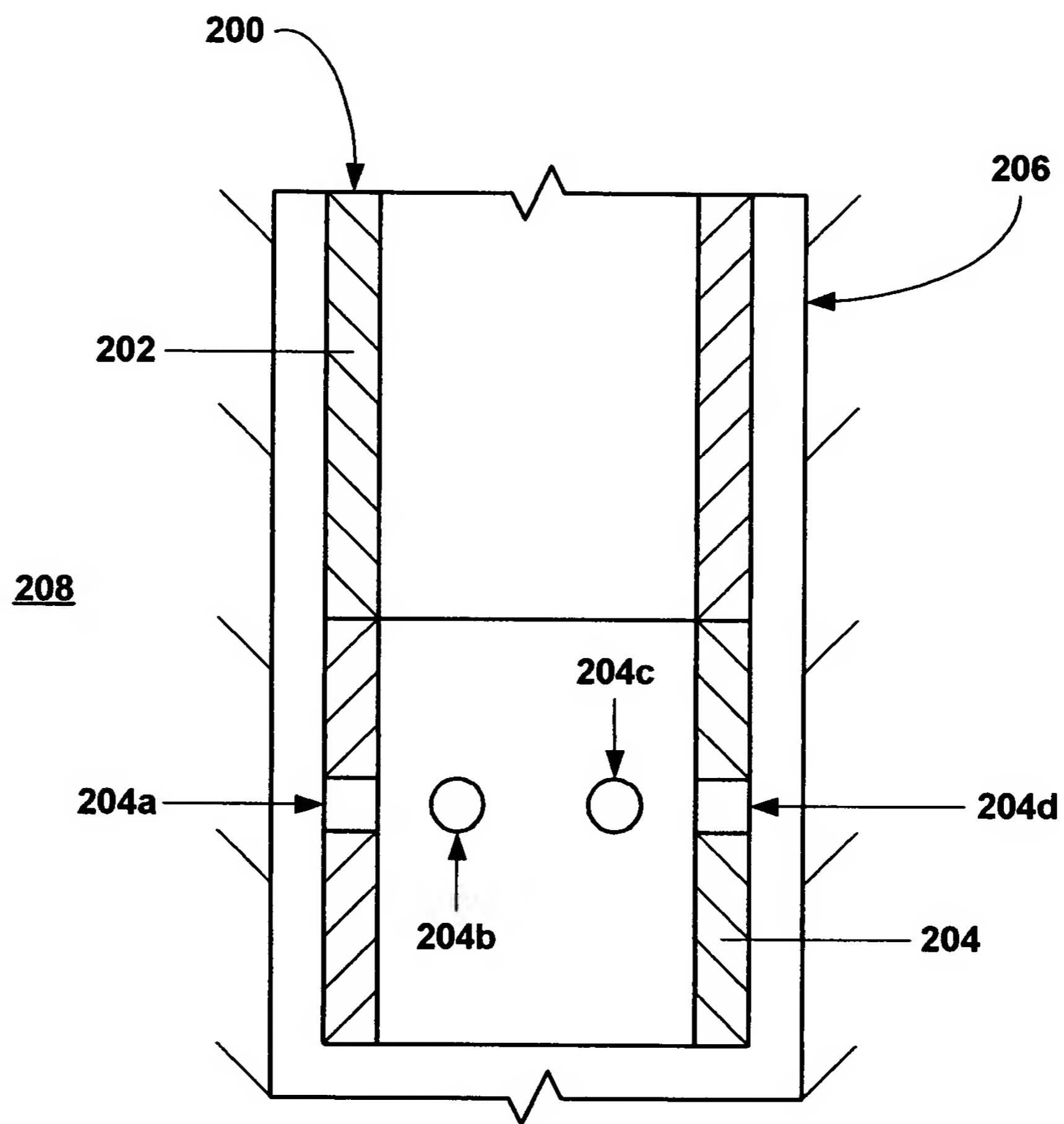


FIG. 14

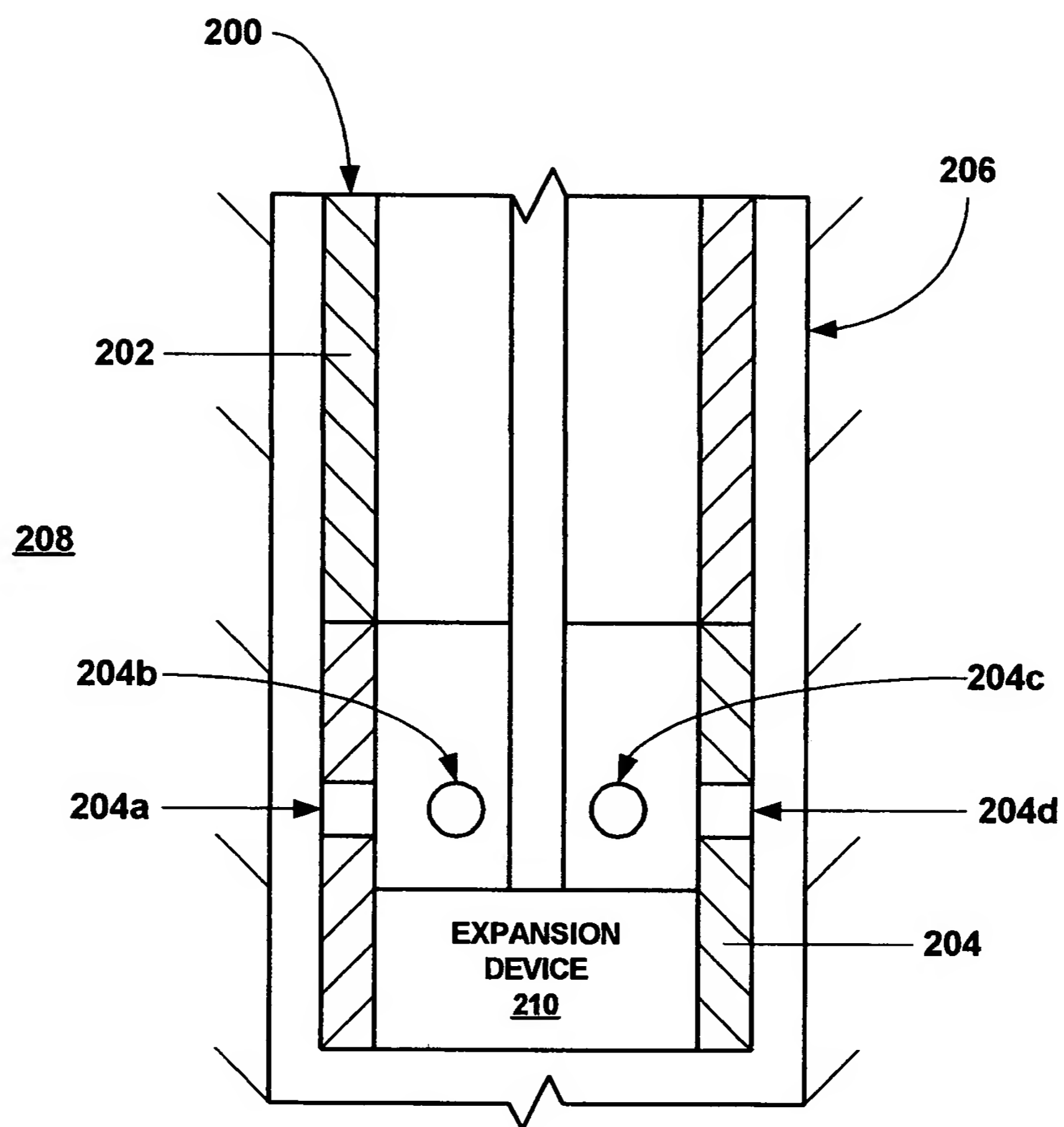


FIG. 15

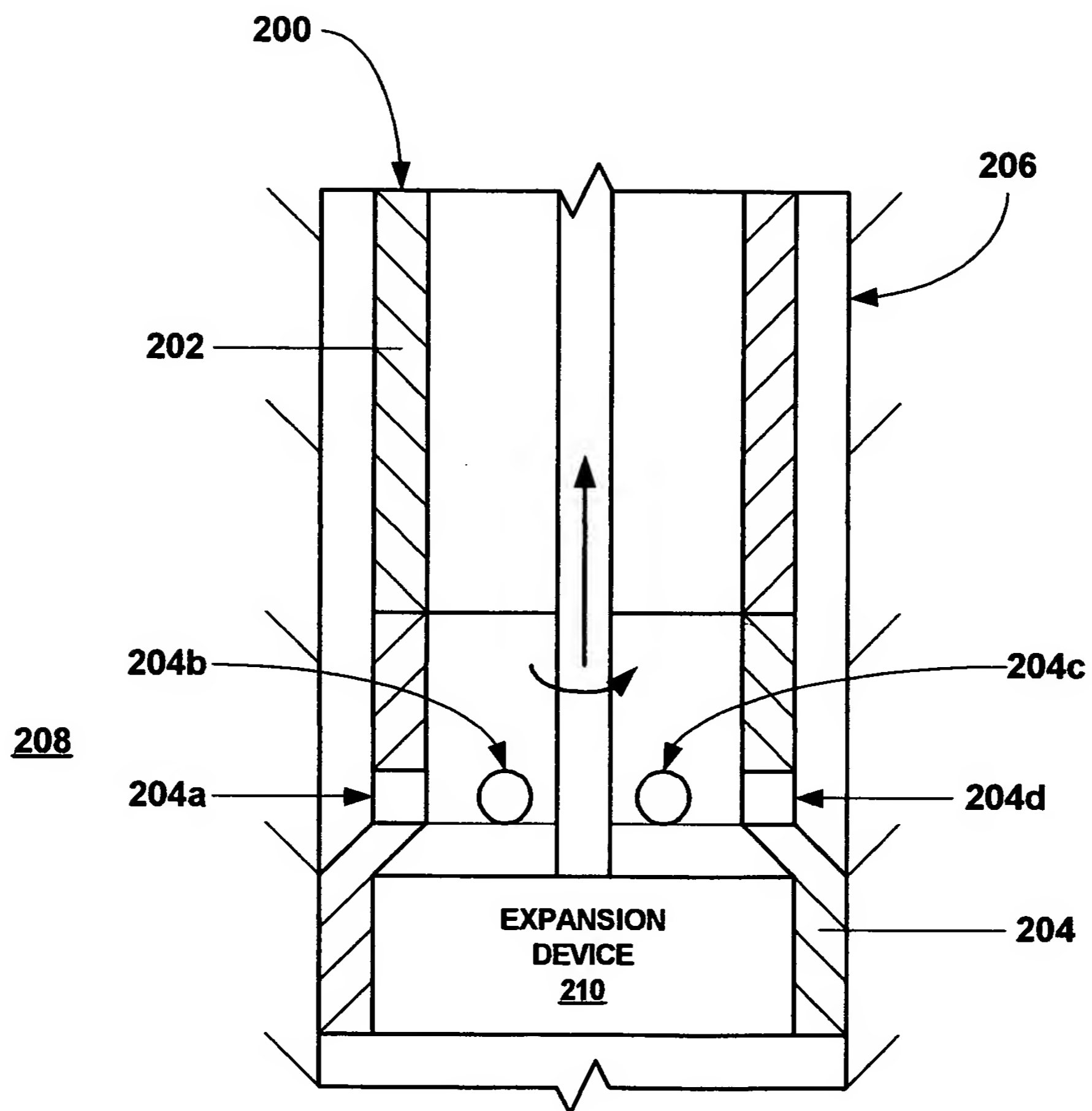


FIG. 16

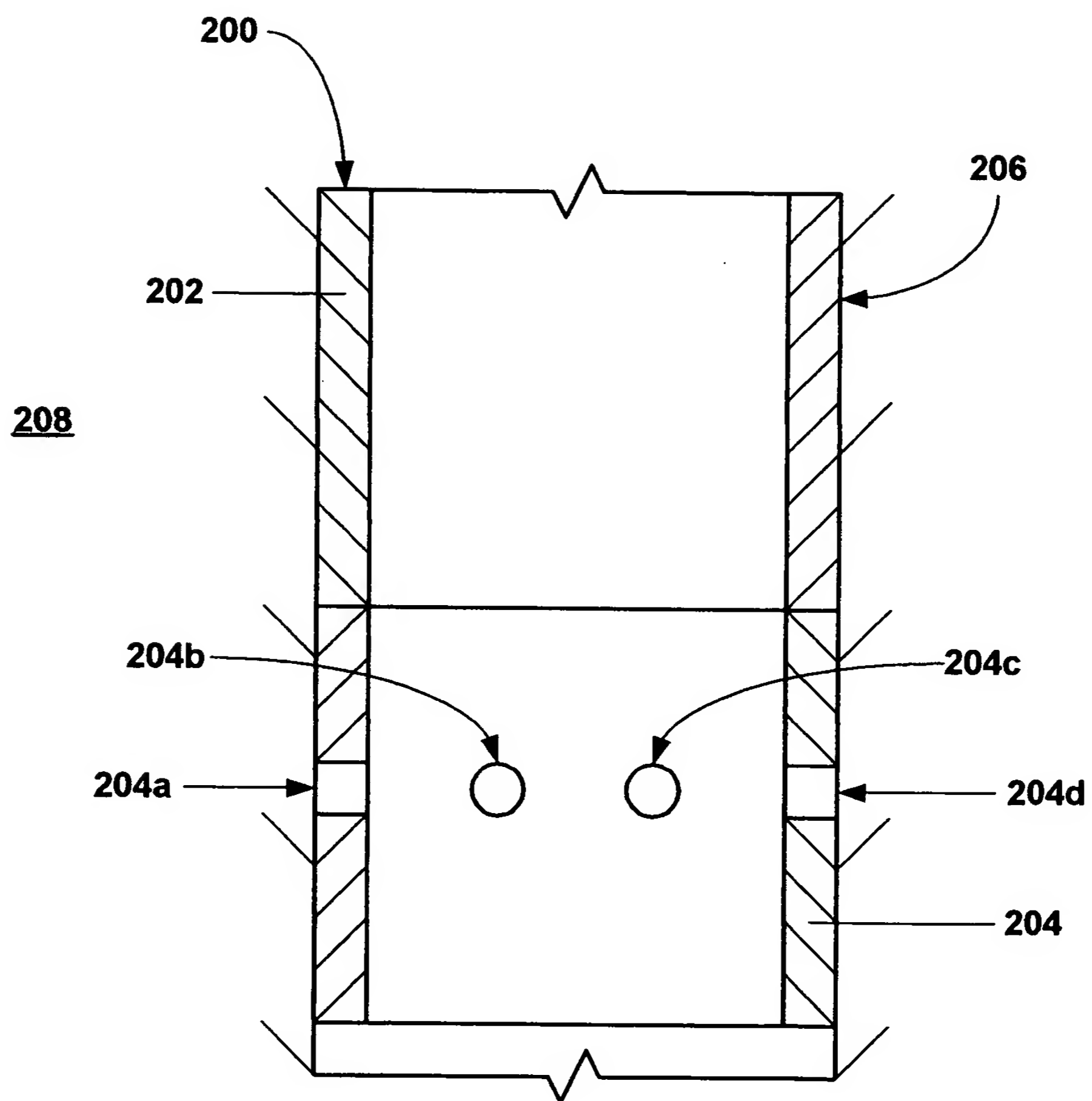


FIG. 17

300

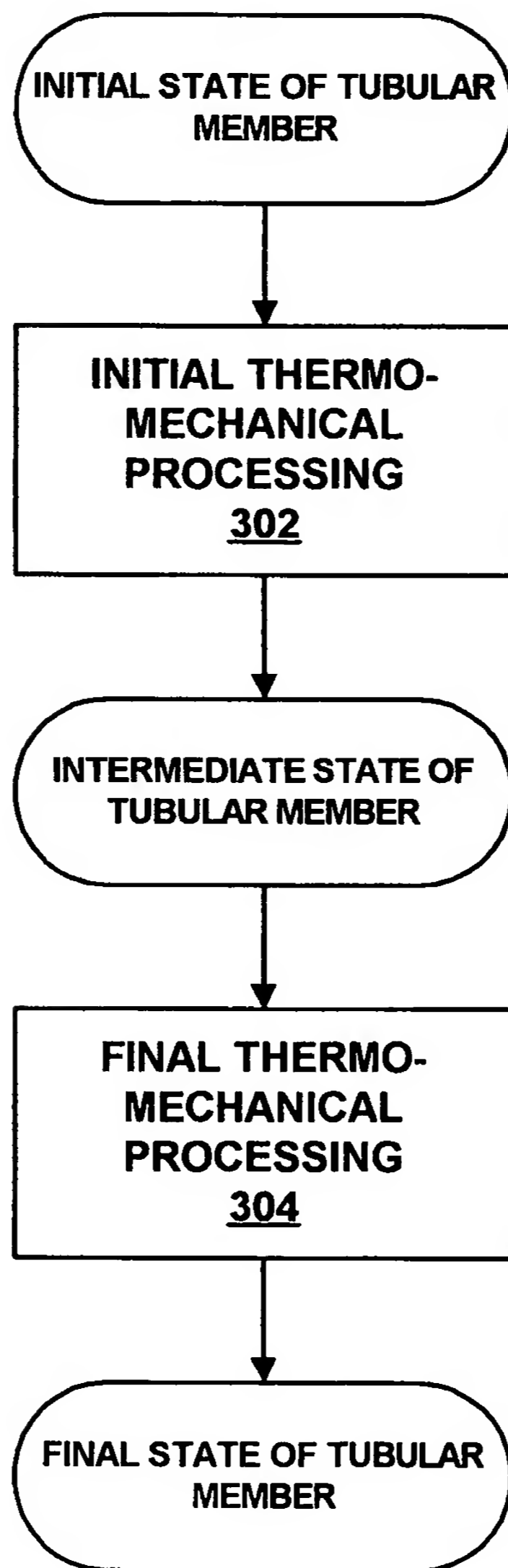



Fig. 18

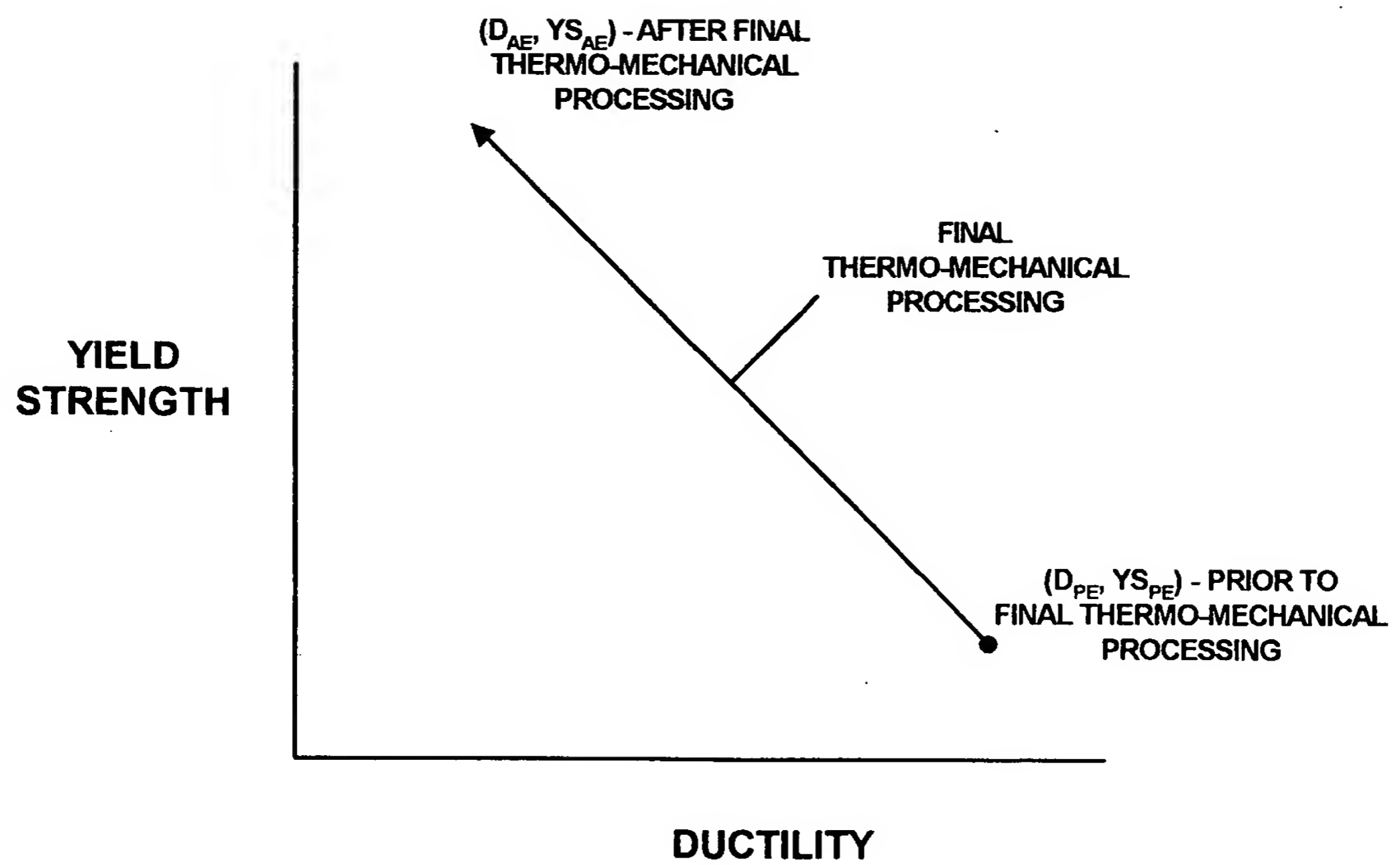


FIG. 19

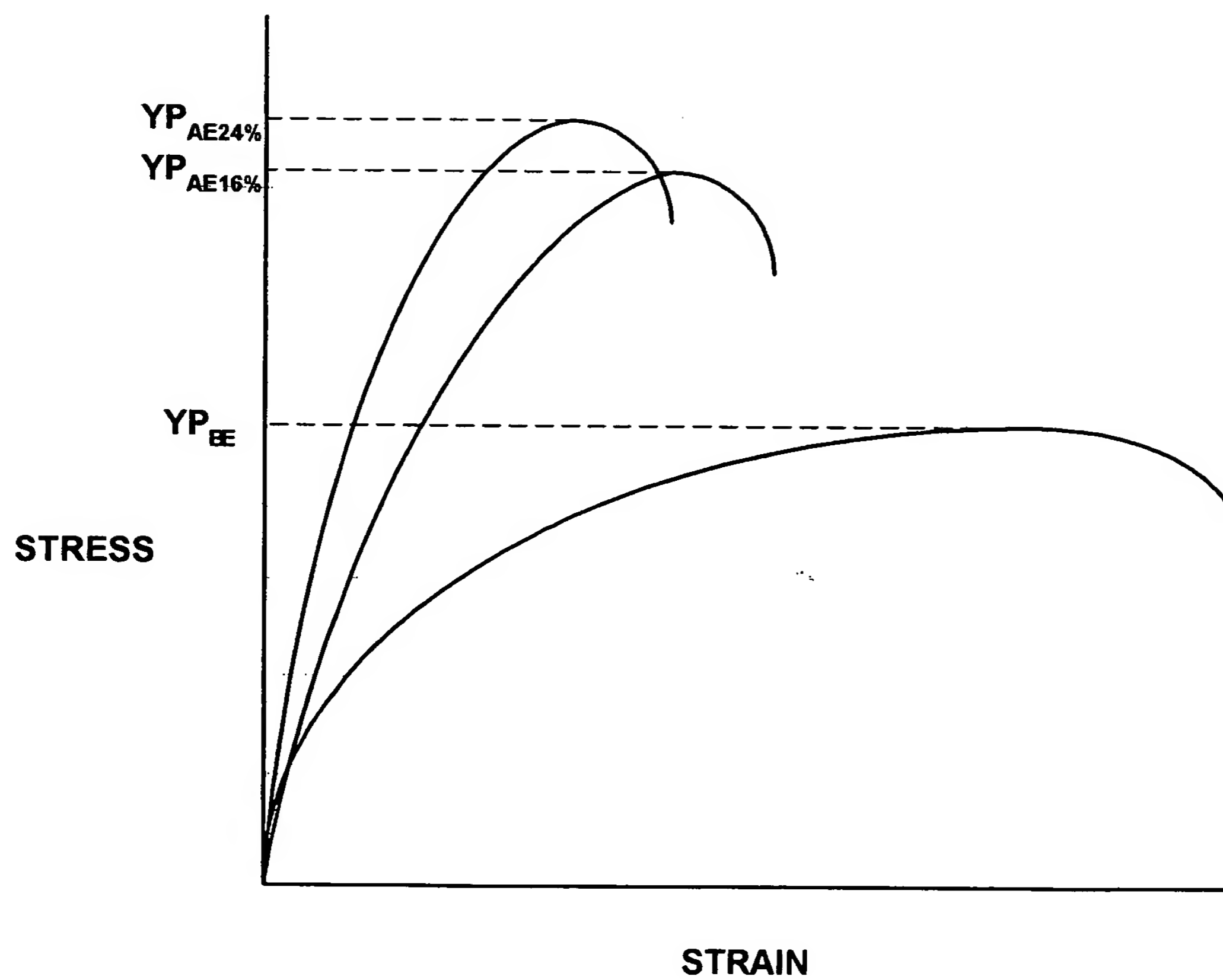


FIG. 20

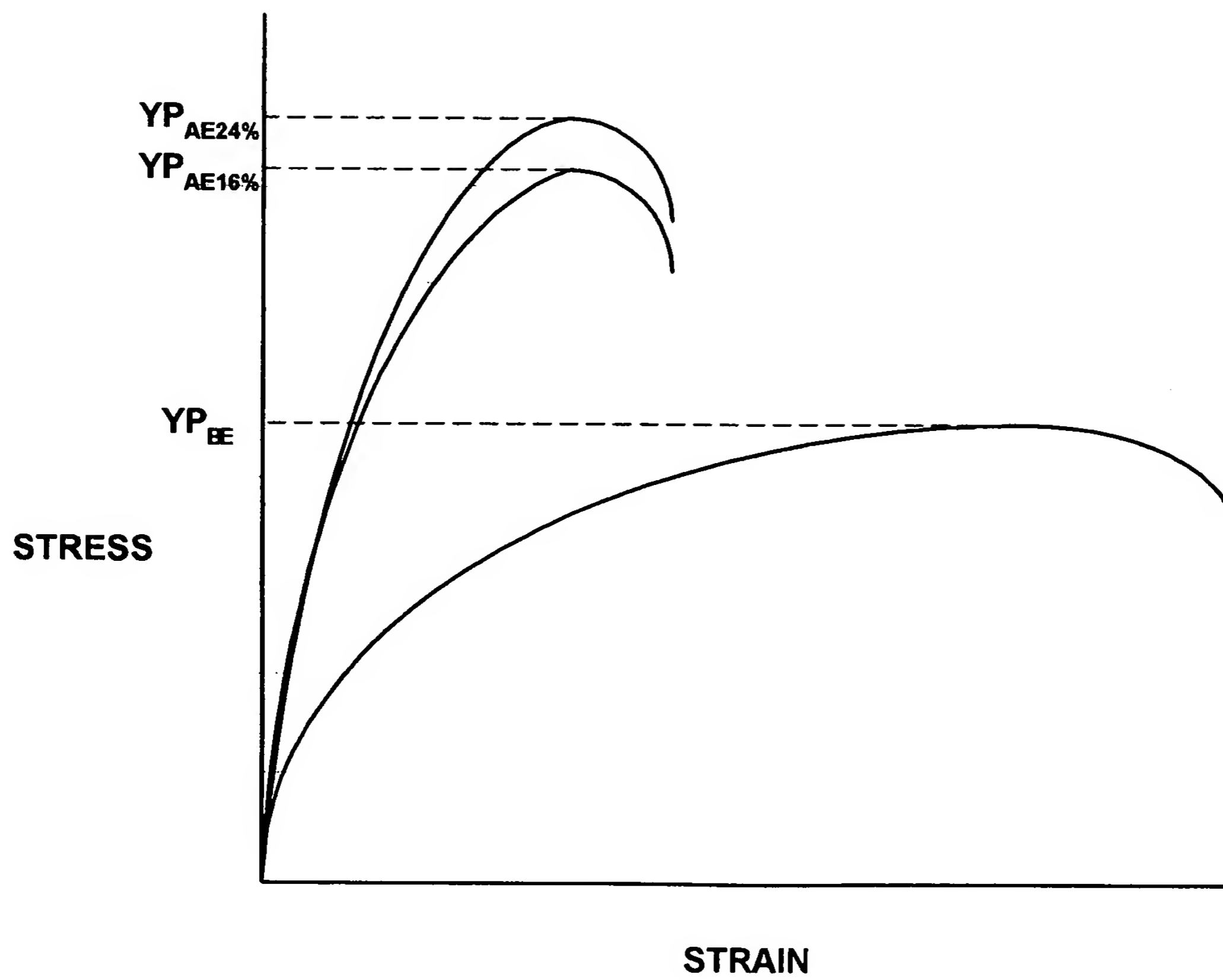


FIG. 21

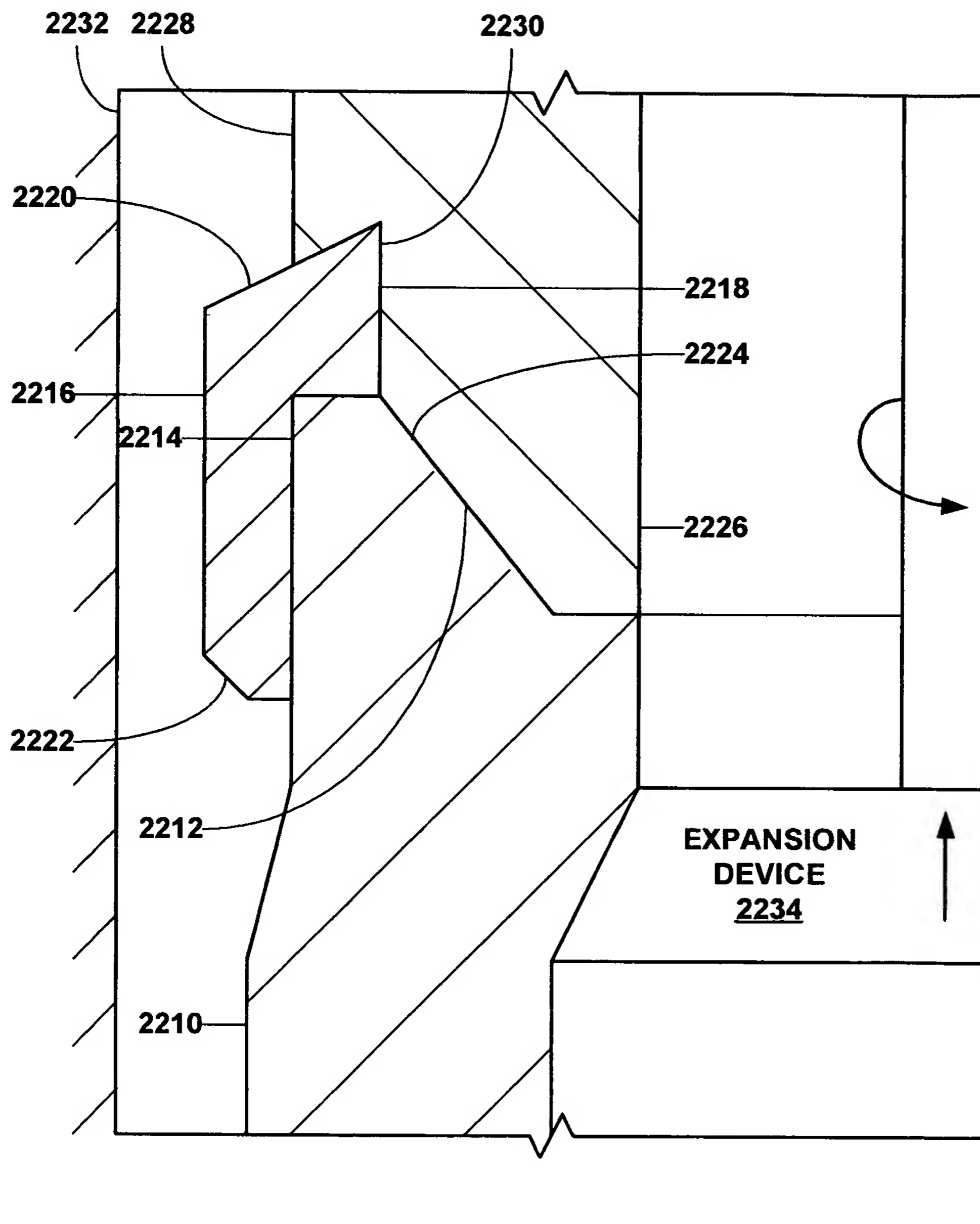


FIG. 22

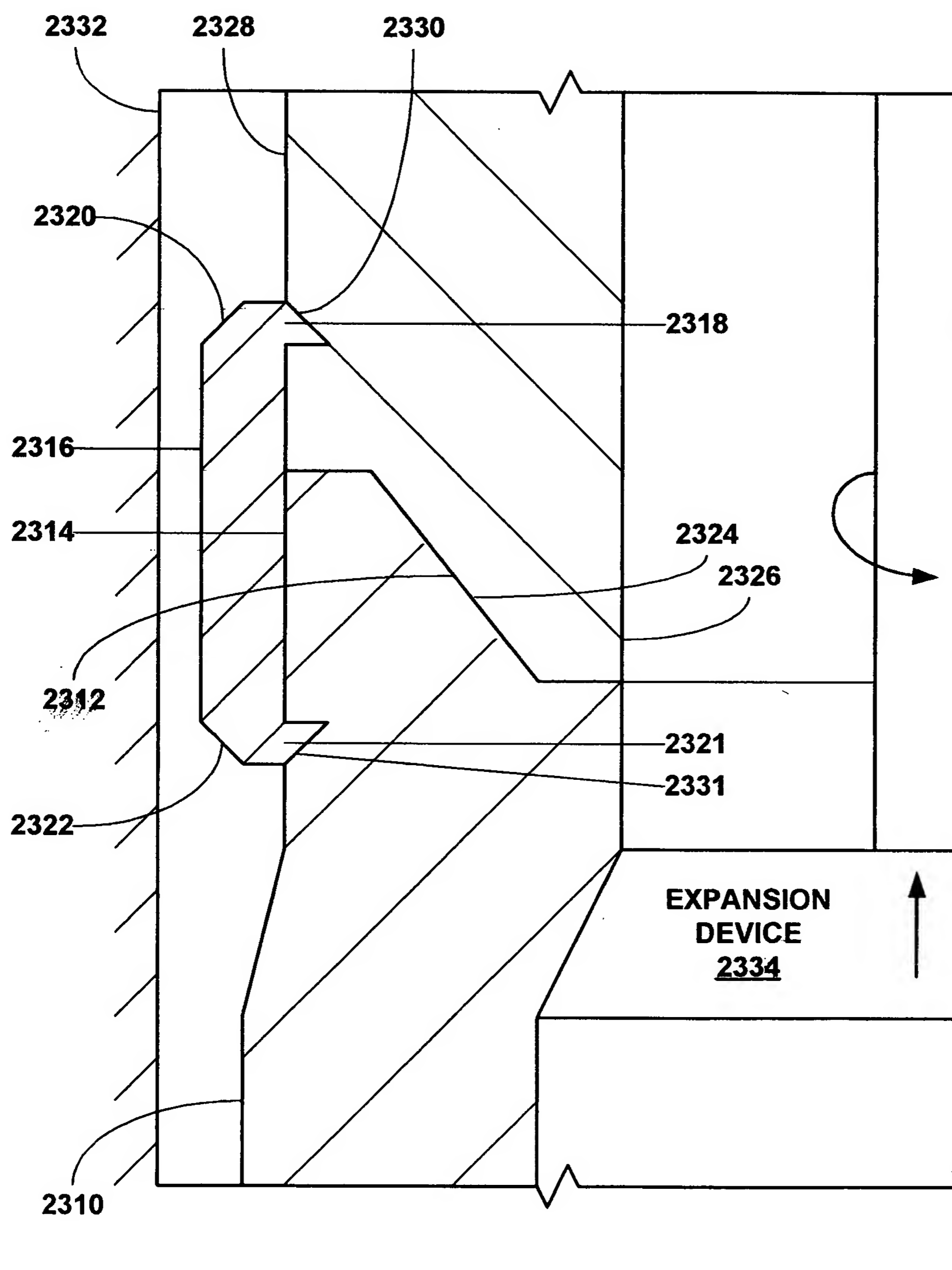


FIG. 23

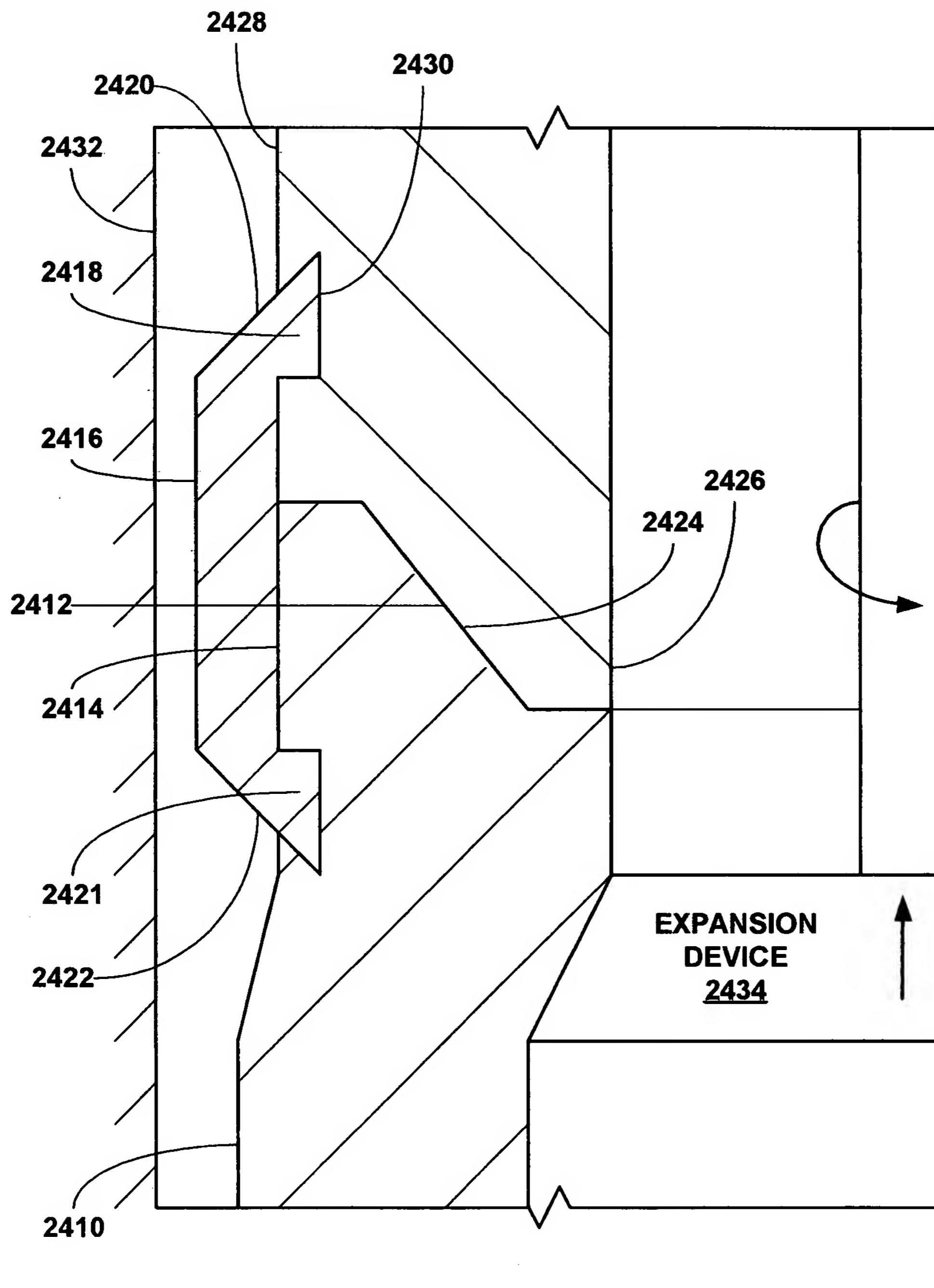


FIG. 24

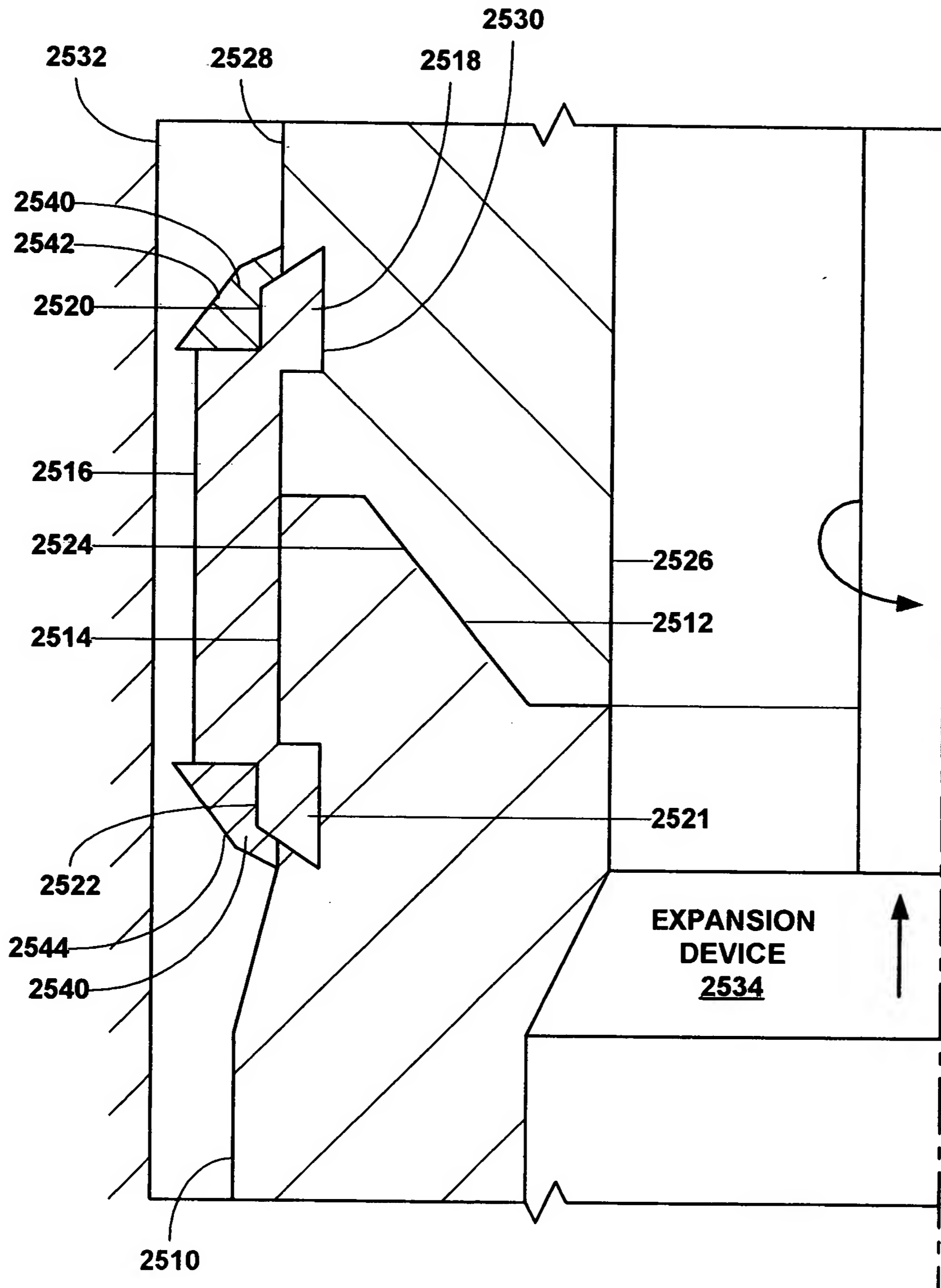


FIG. 25

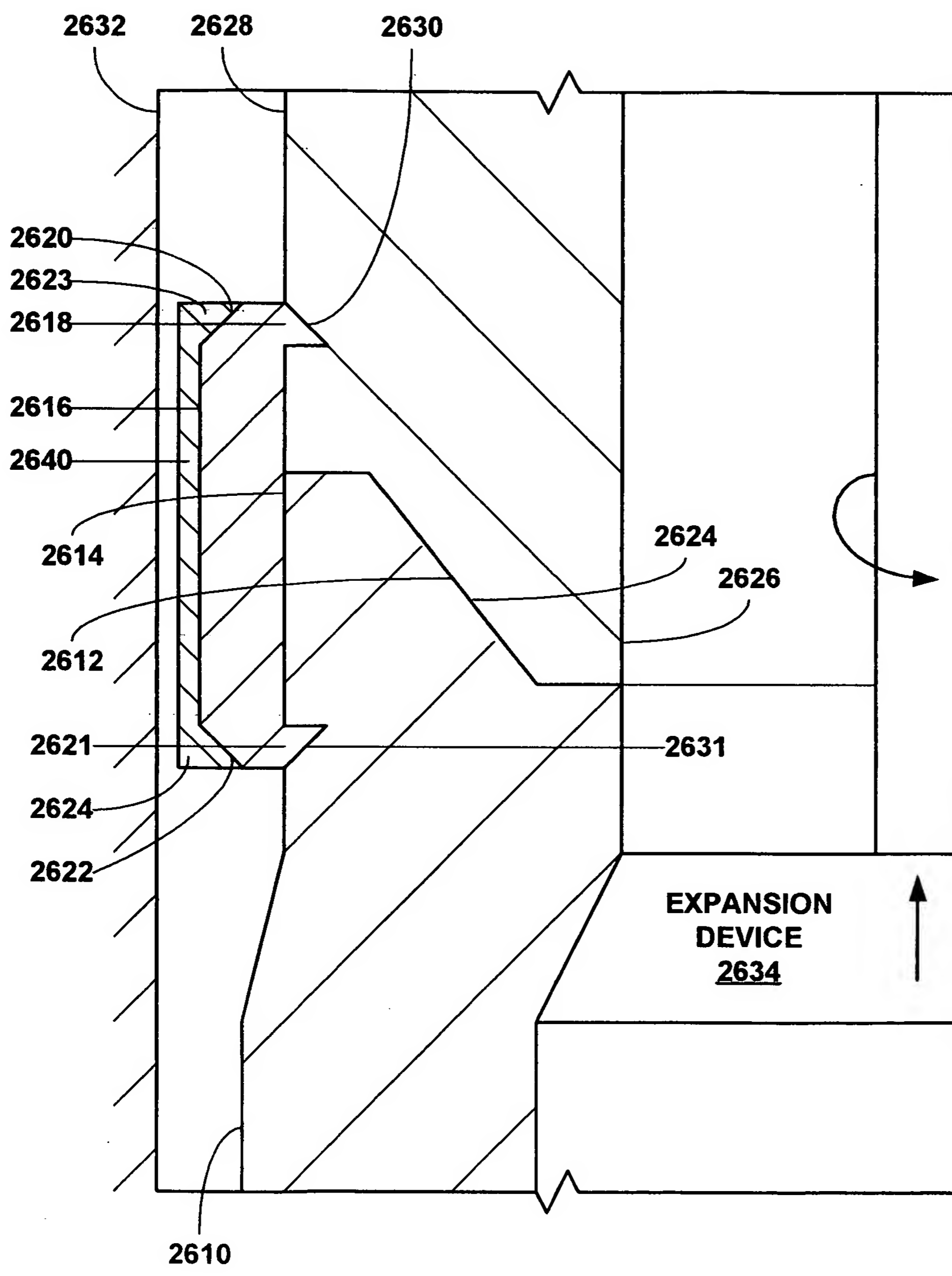


FIG. 26

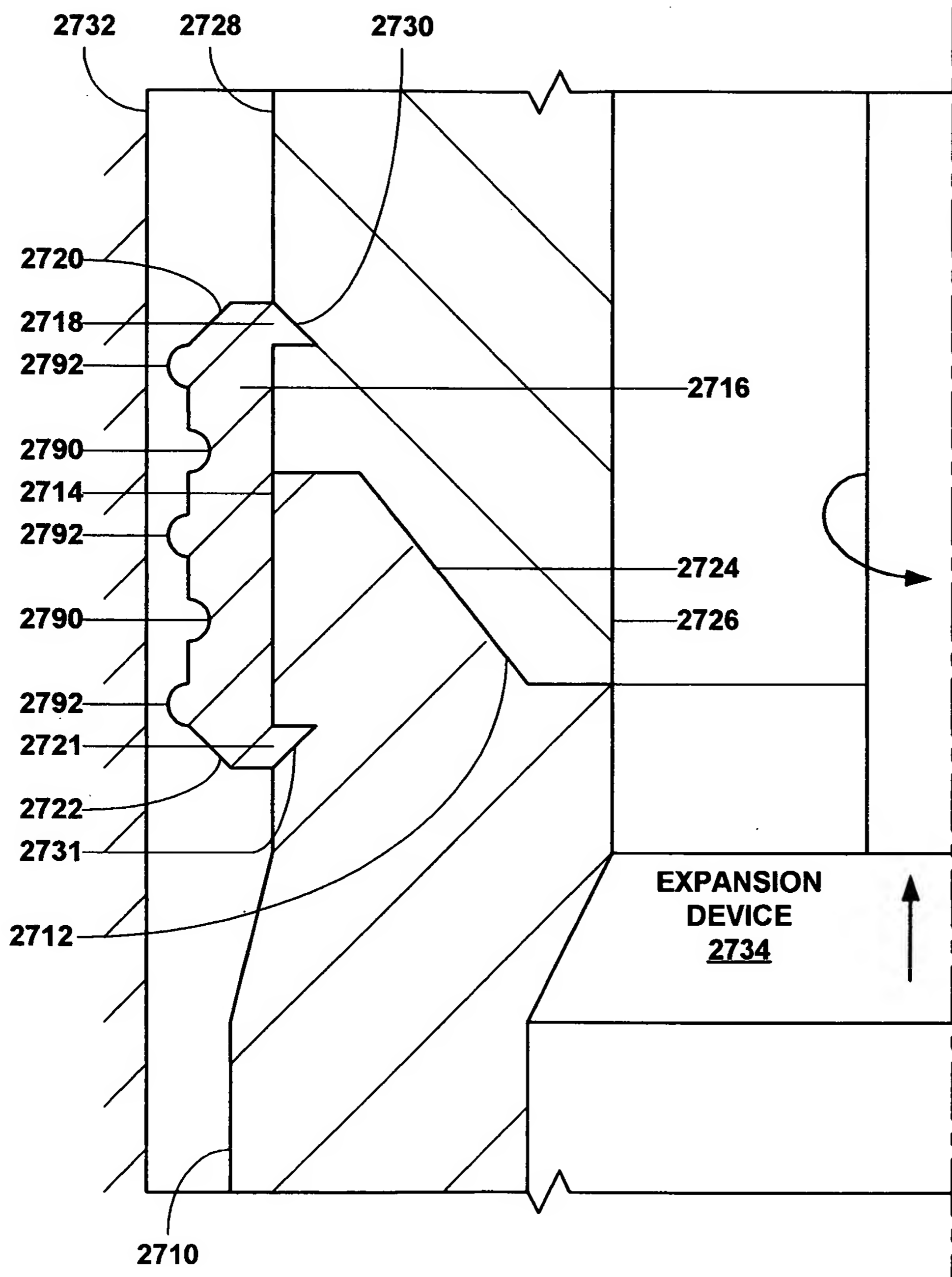


FIG. 27

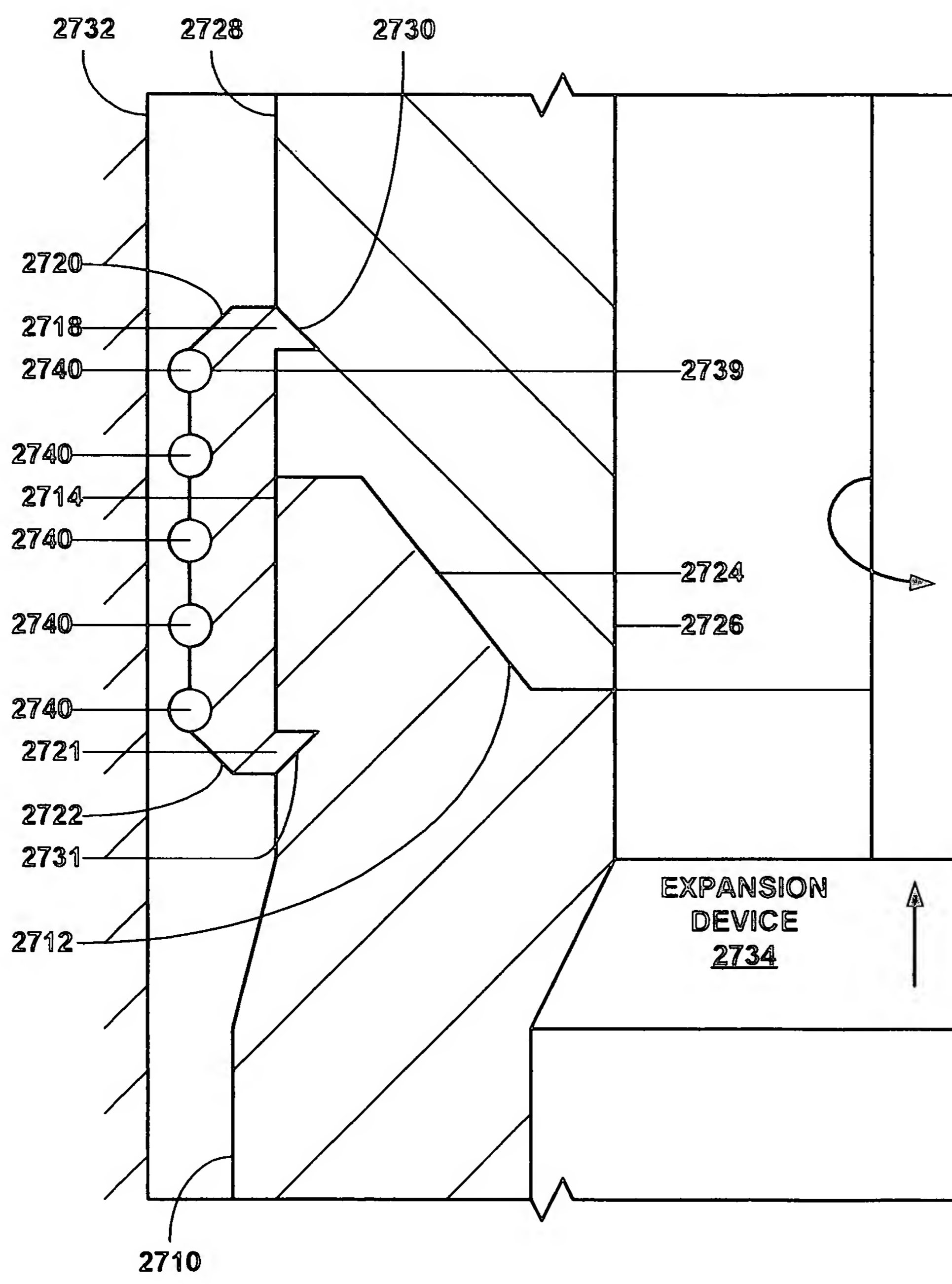


FIG. 28

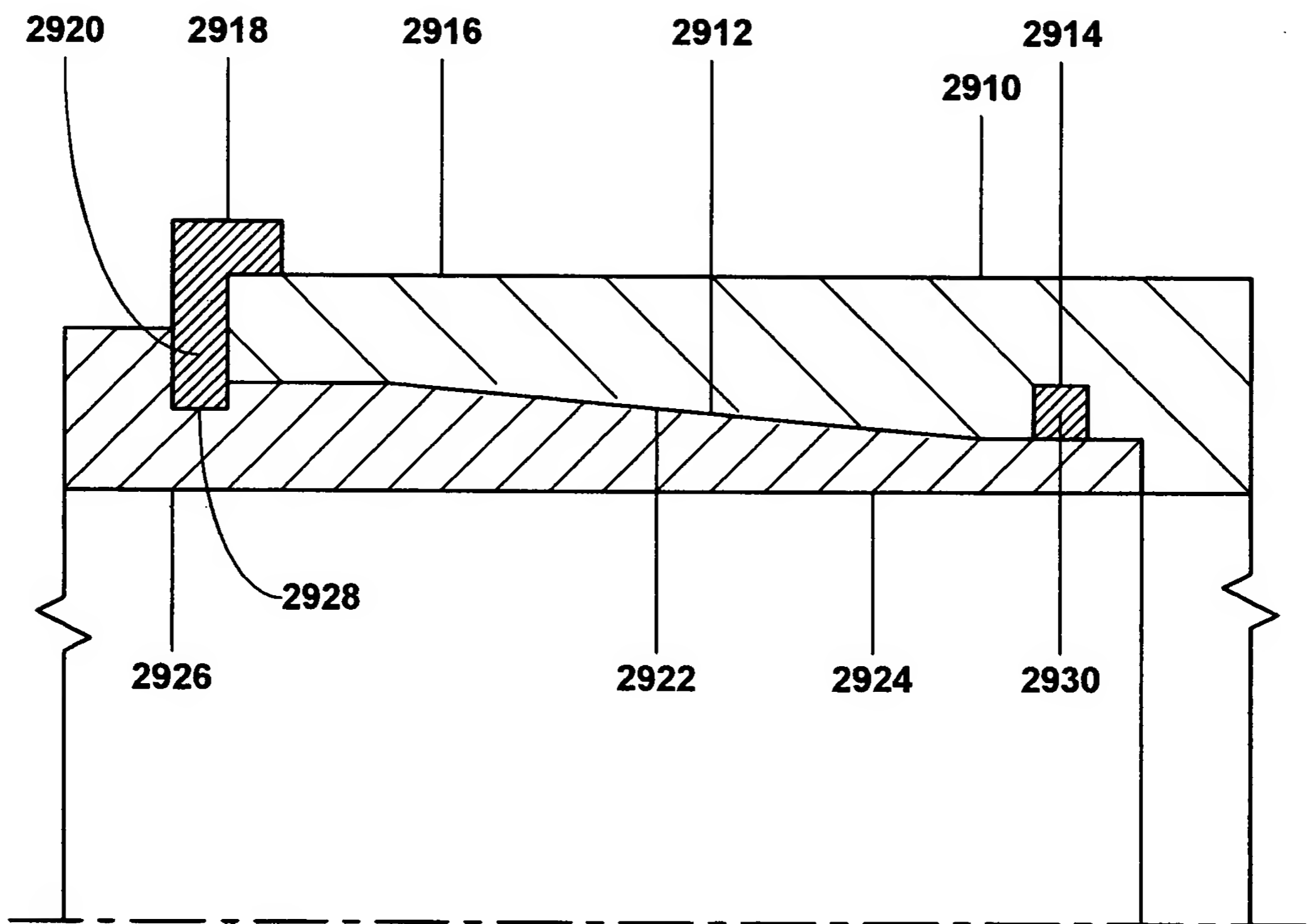


FIG. 29

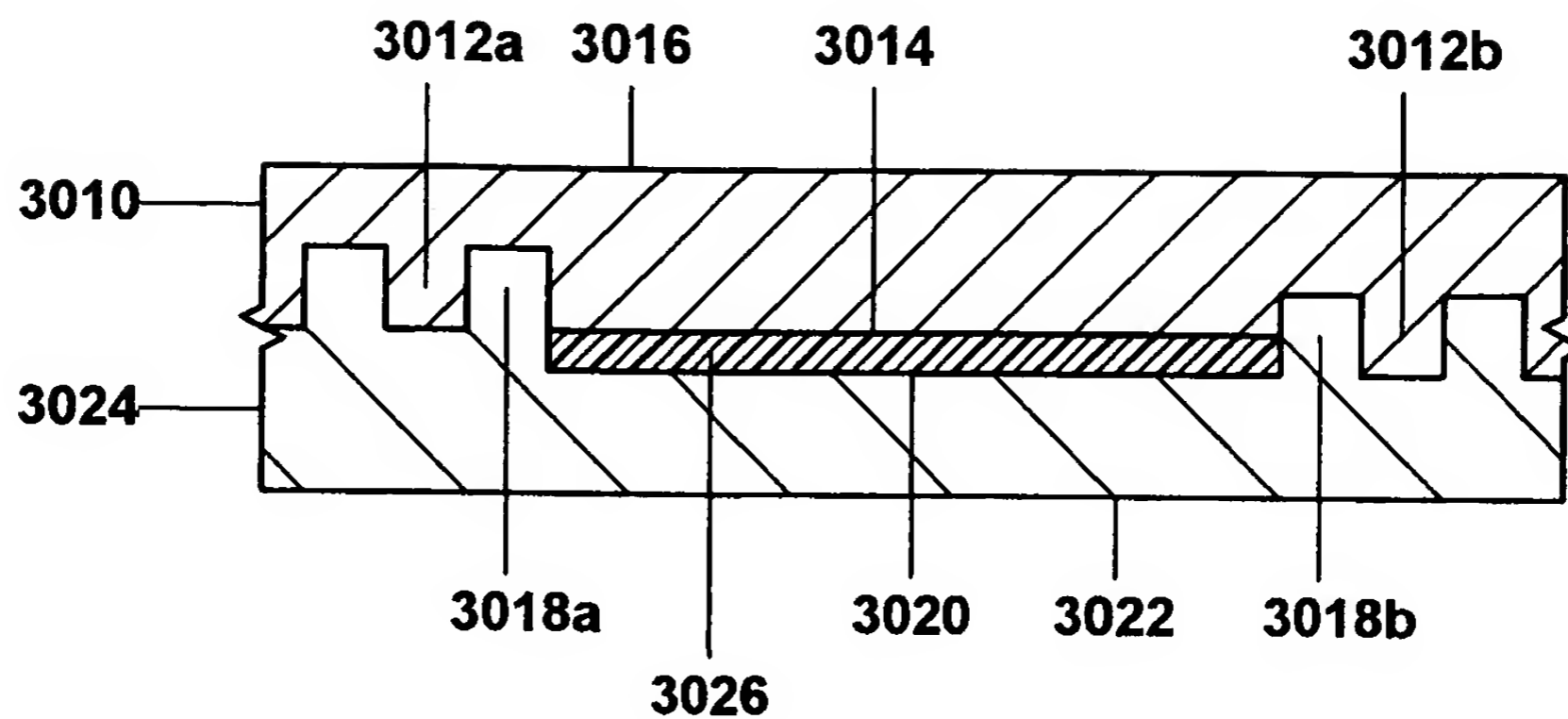


FIG. 30a

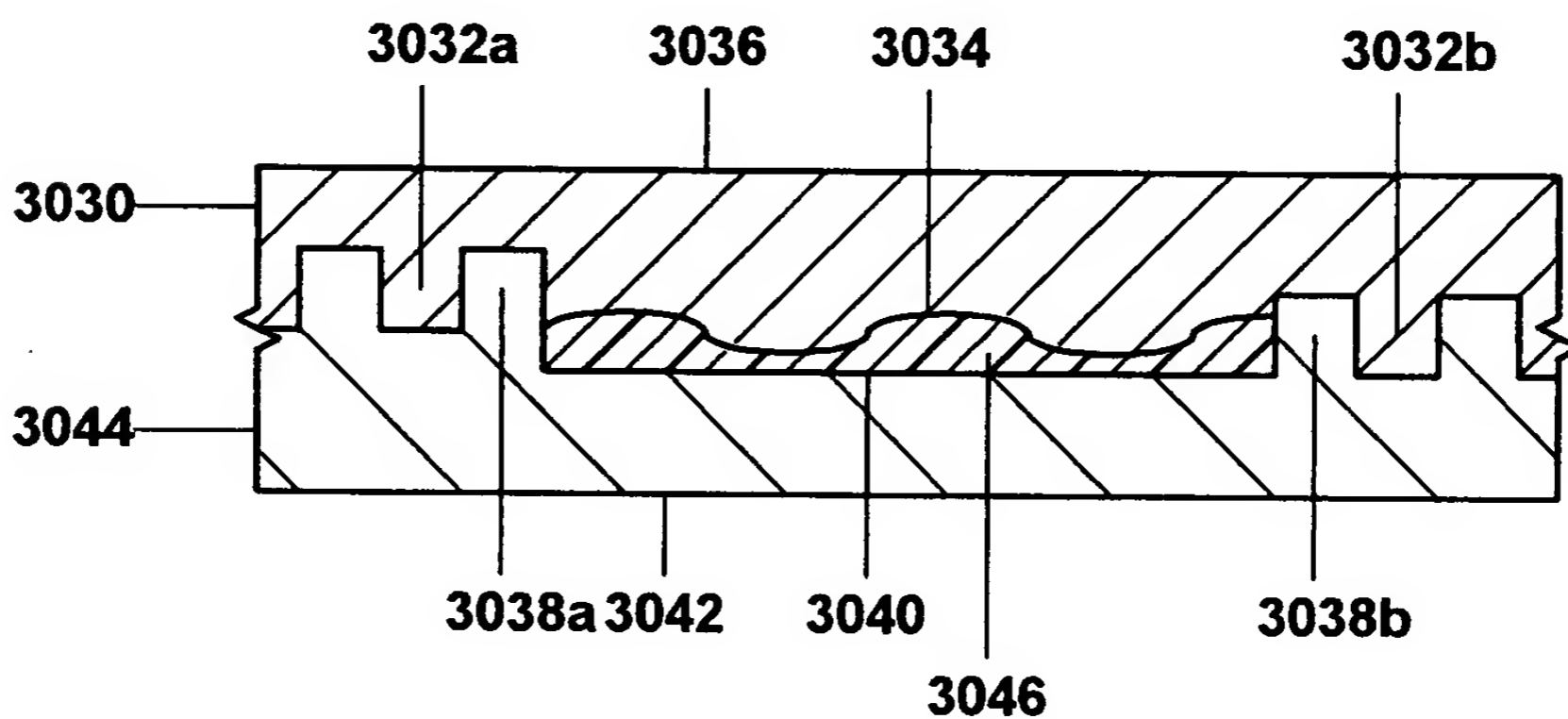


FIG. 30b

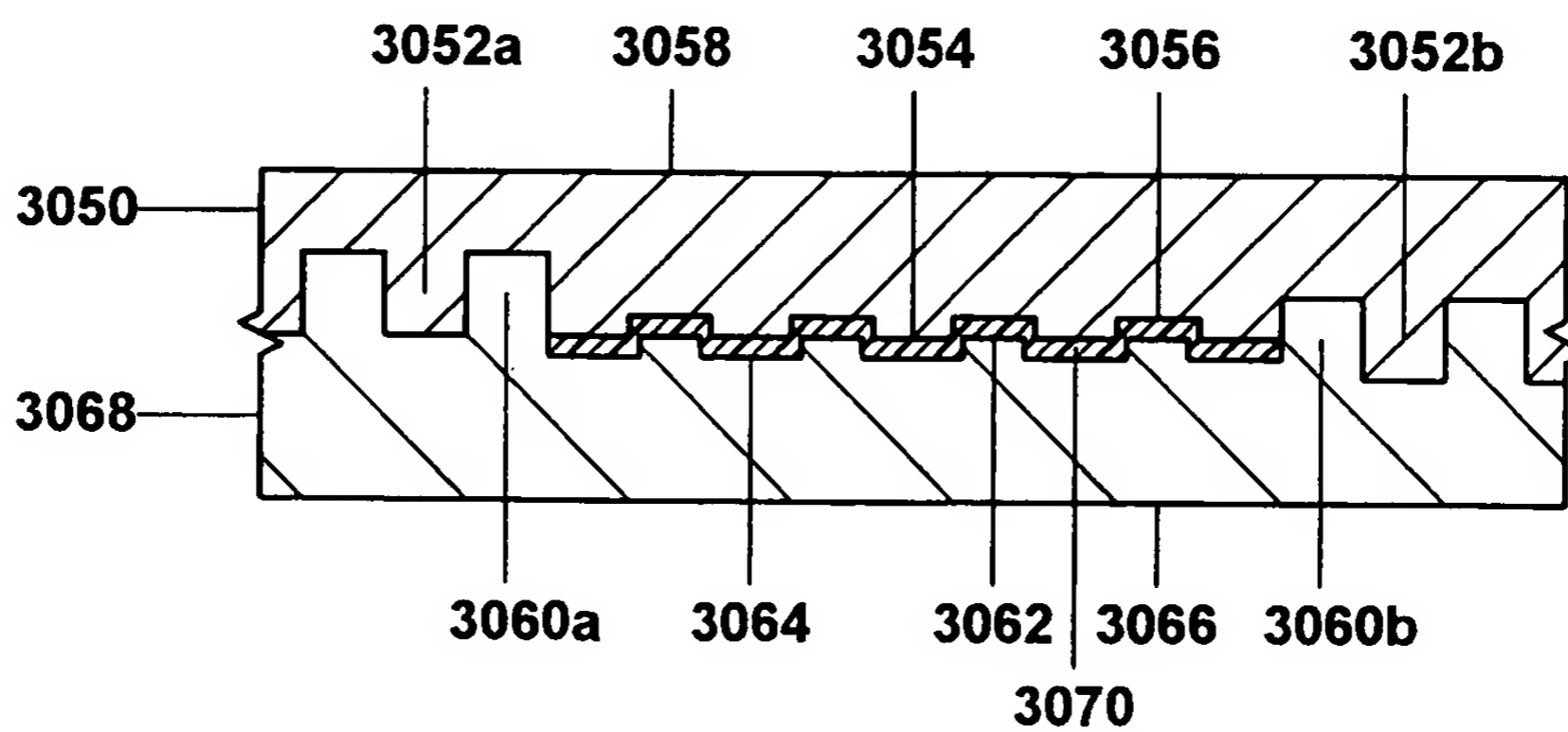


FIG. 30c

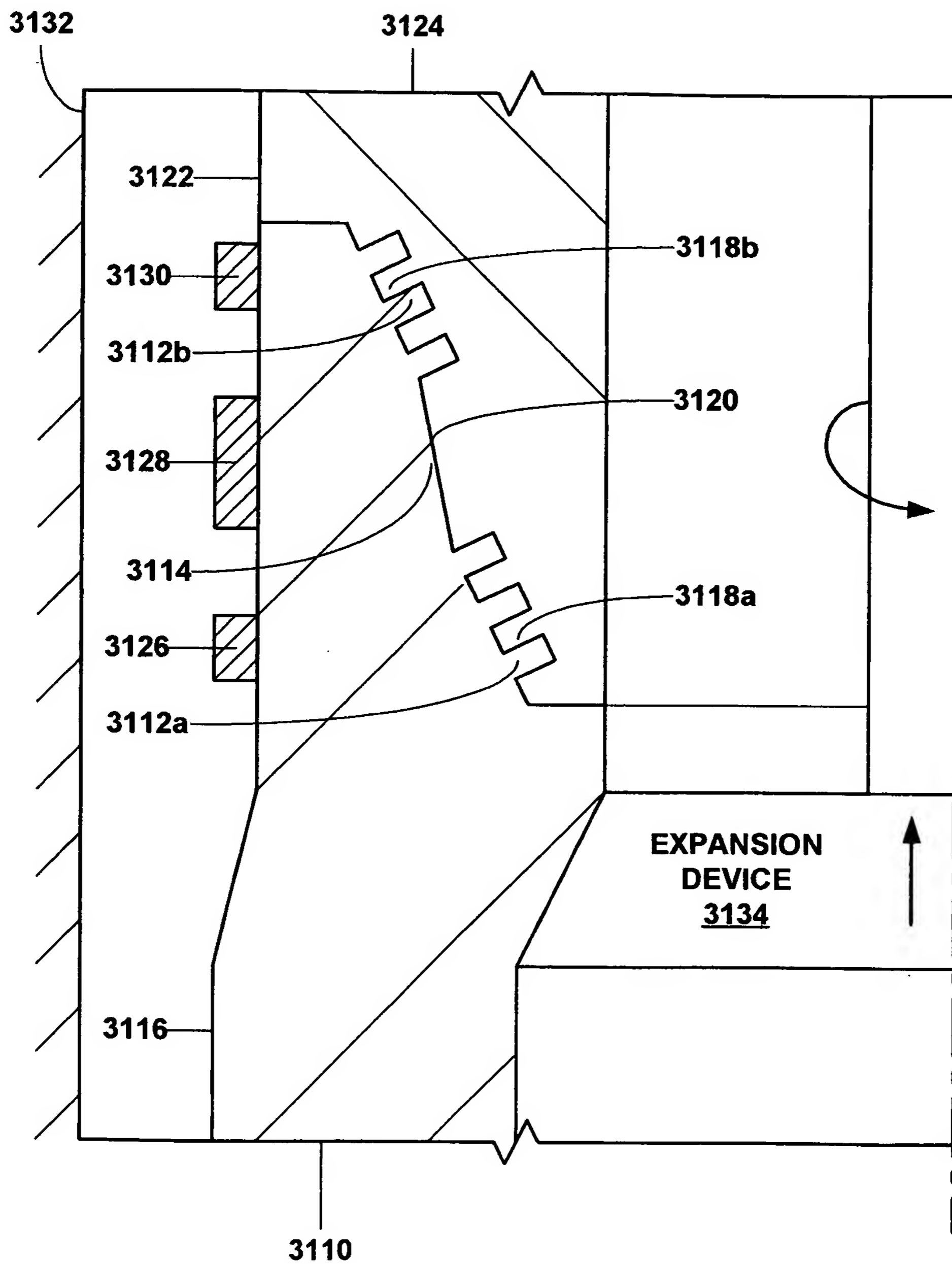


FIG. 31

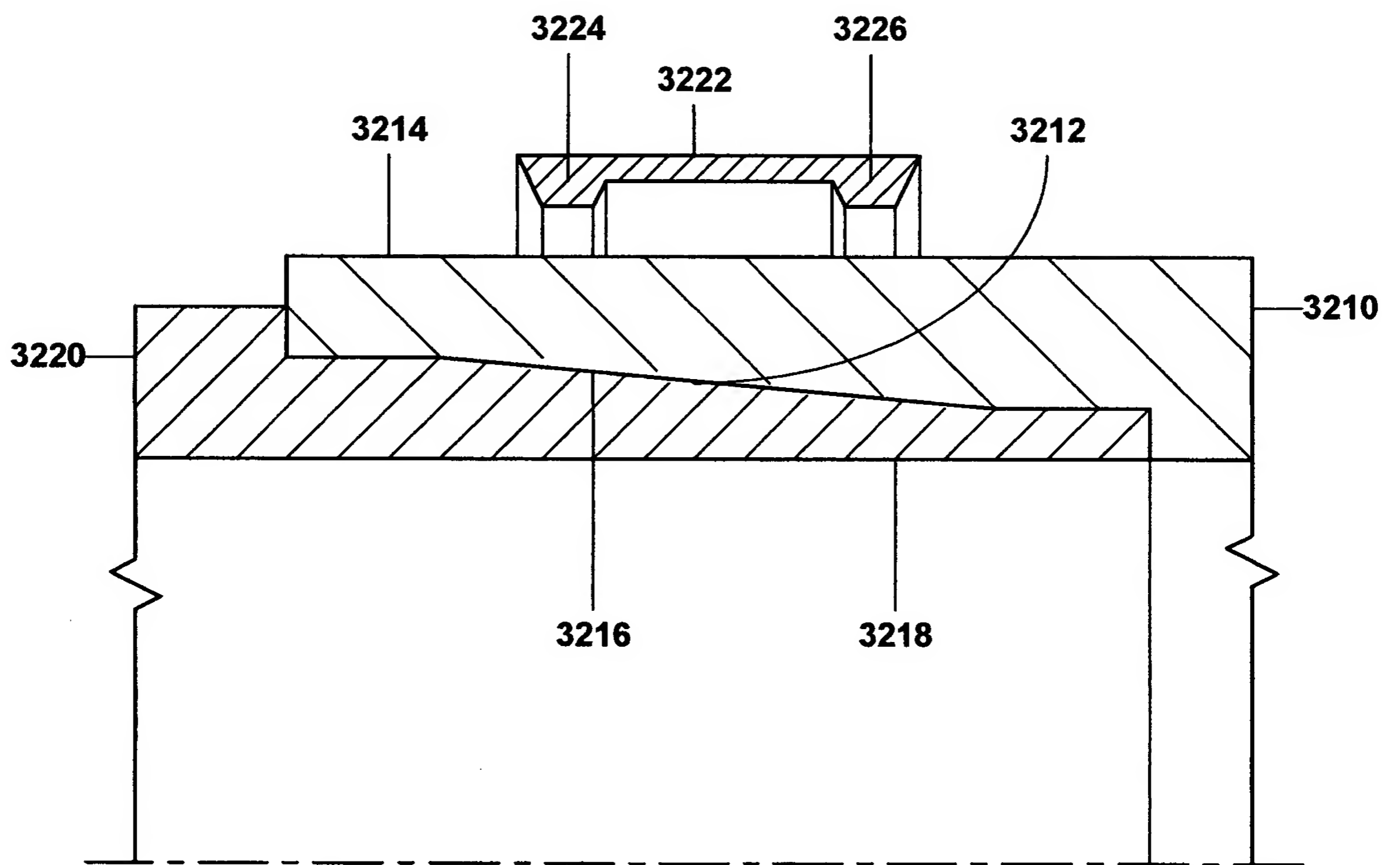


FIG. 32a

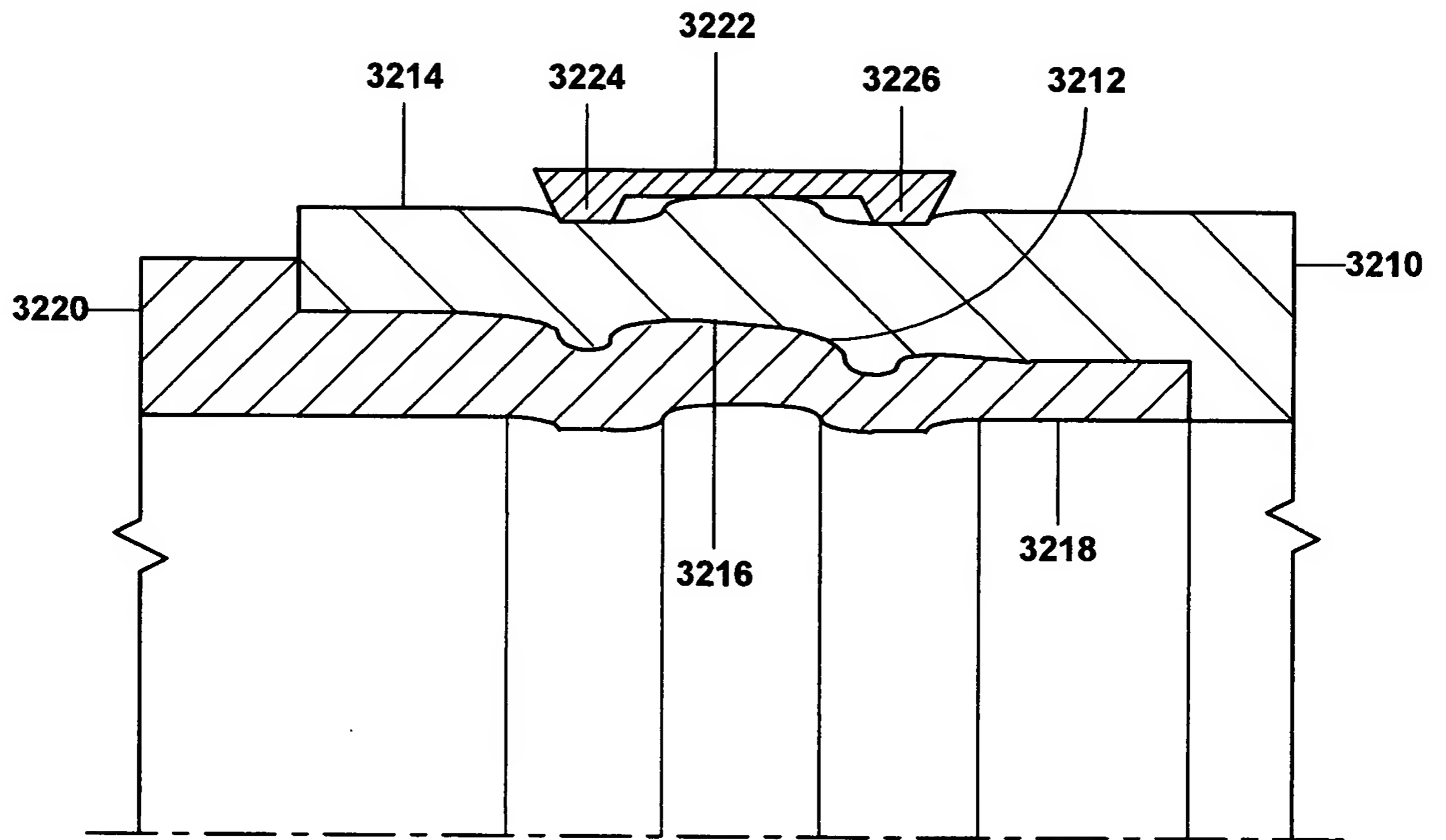


FIG. 32b

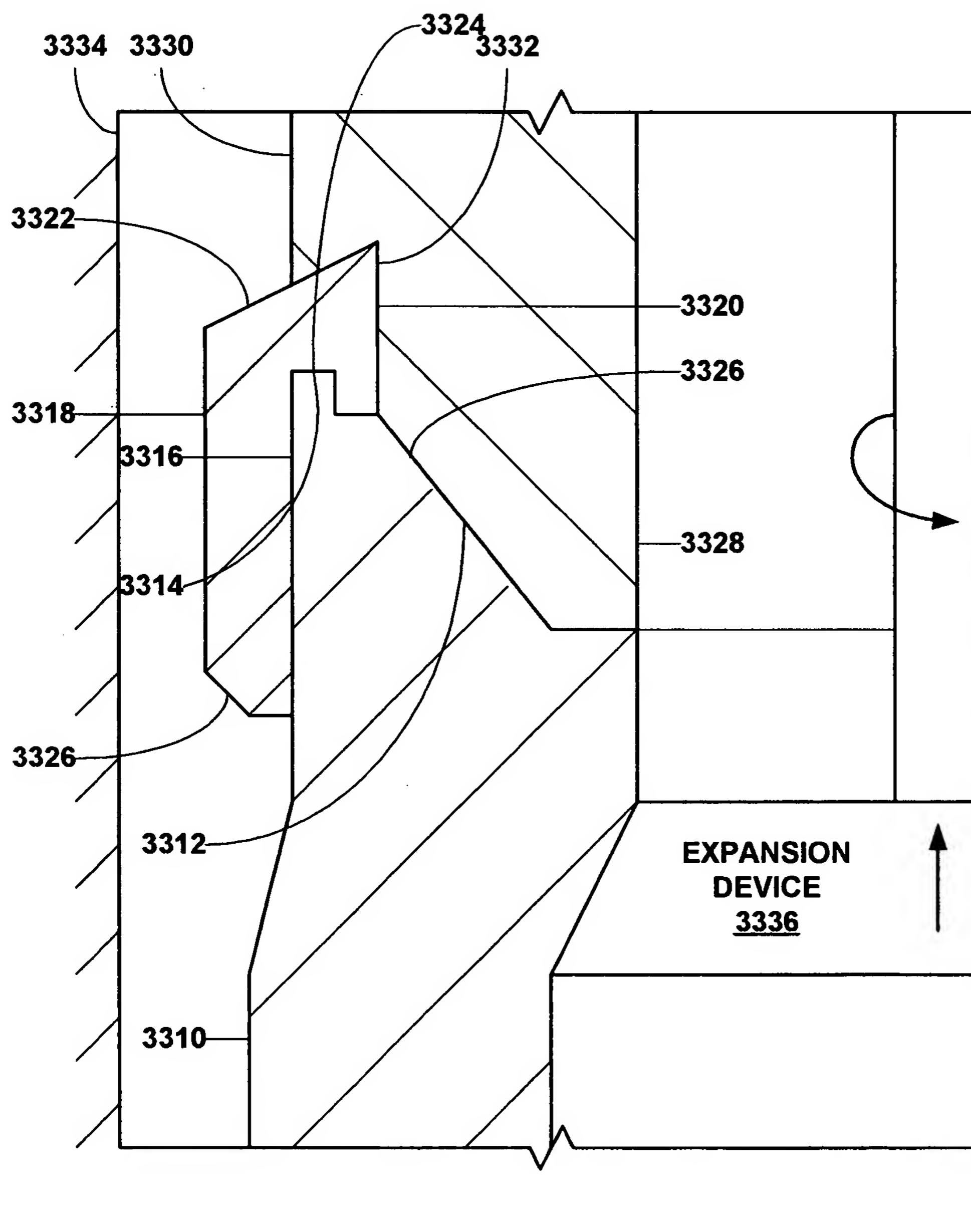


FIG. 33

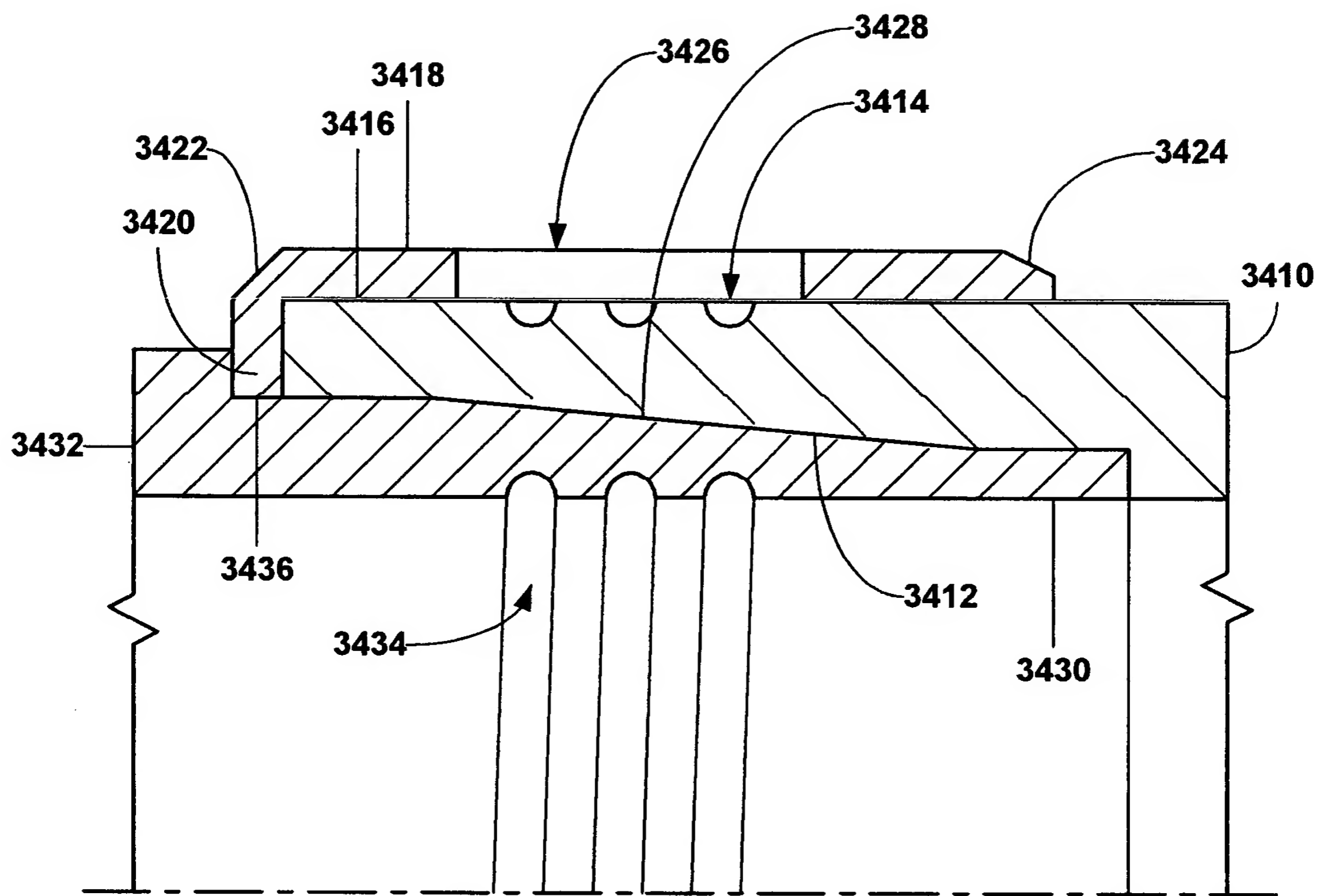


FIG. 34a

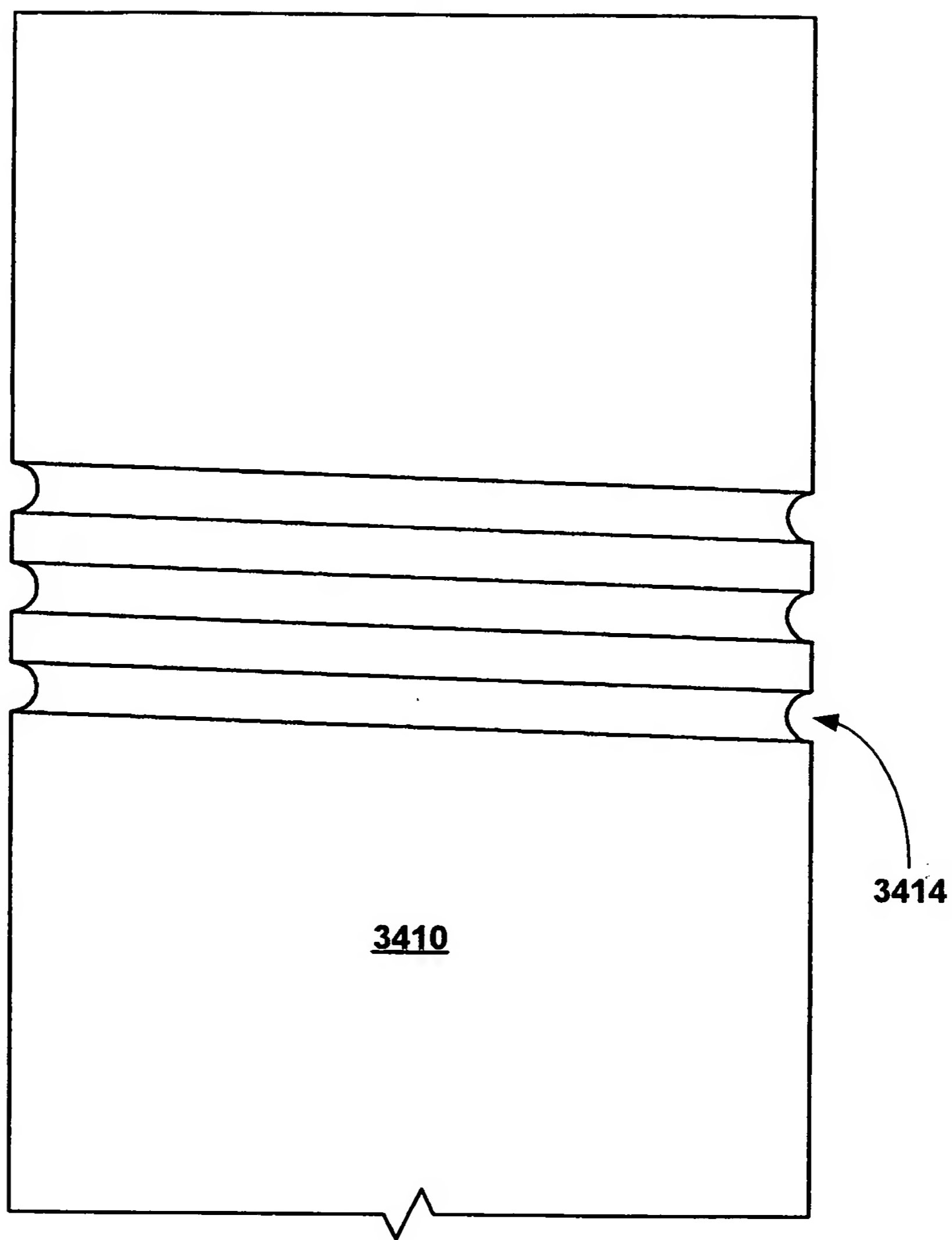


Fig. 34b

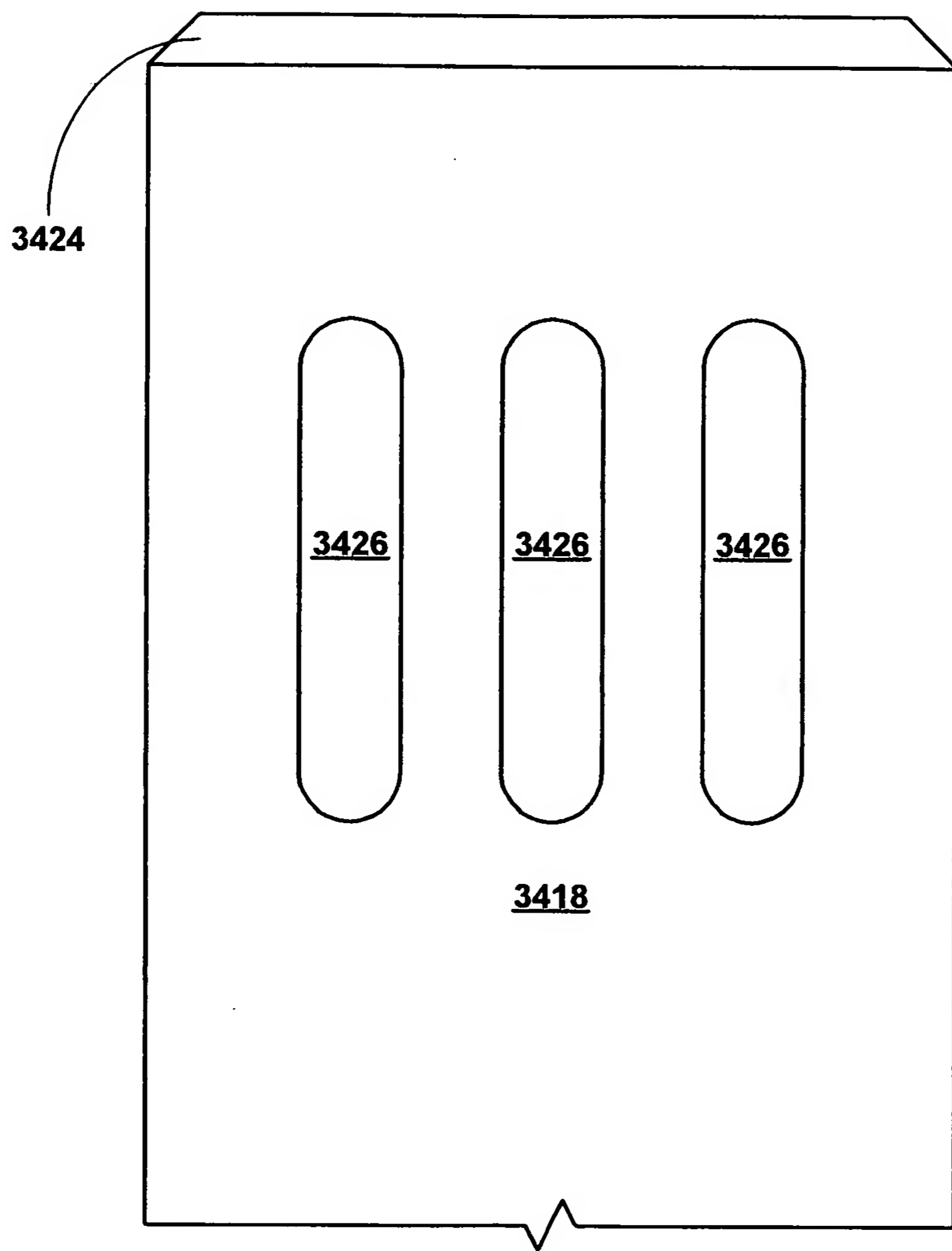


Fig. 34c

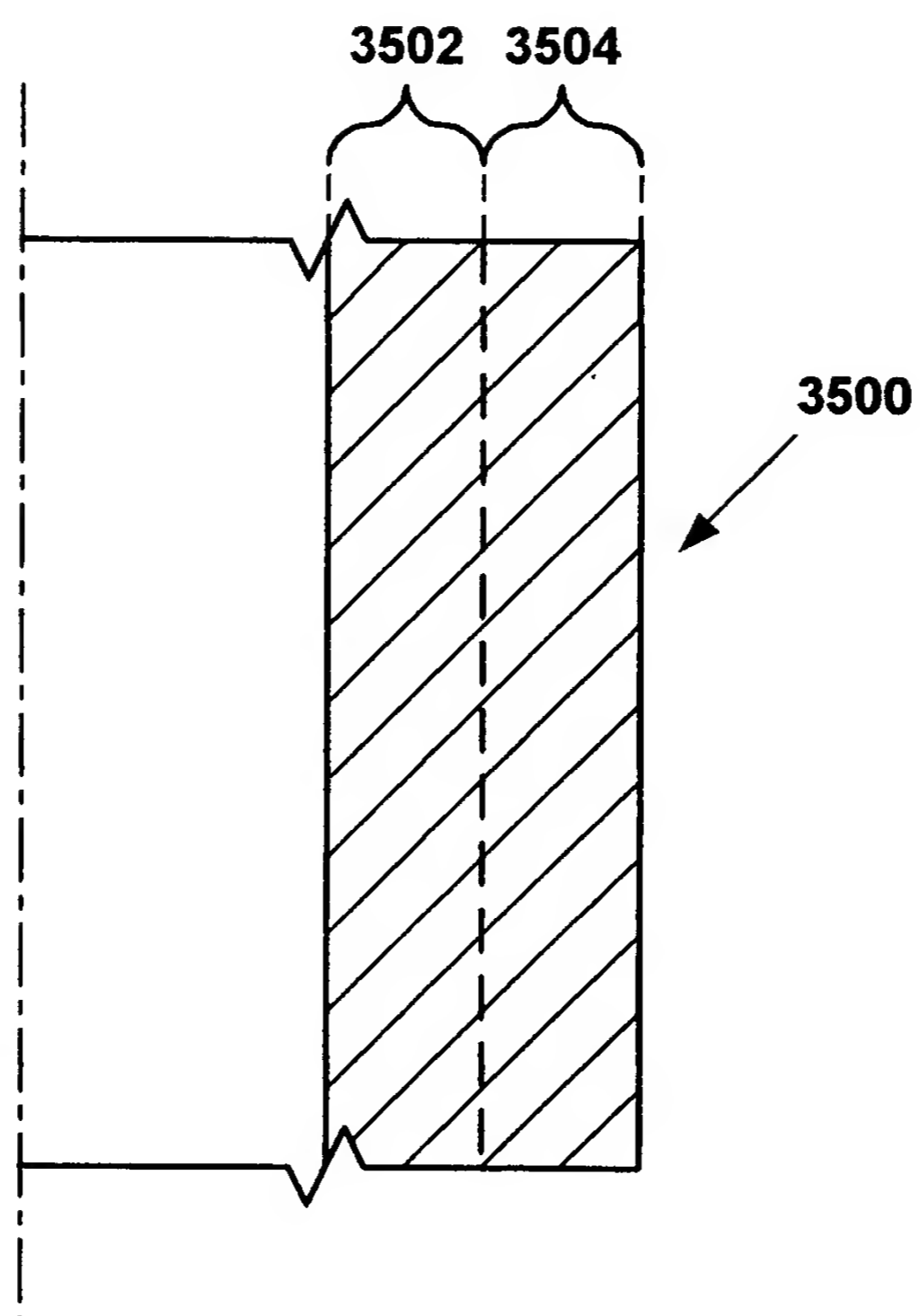


FIG. 35a

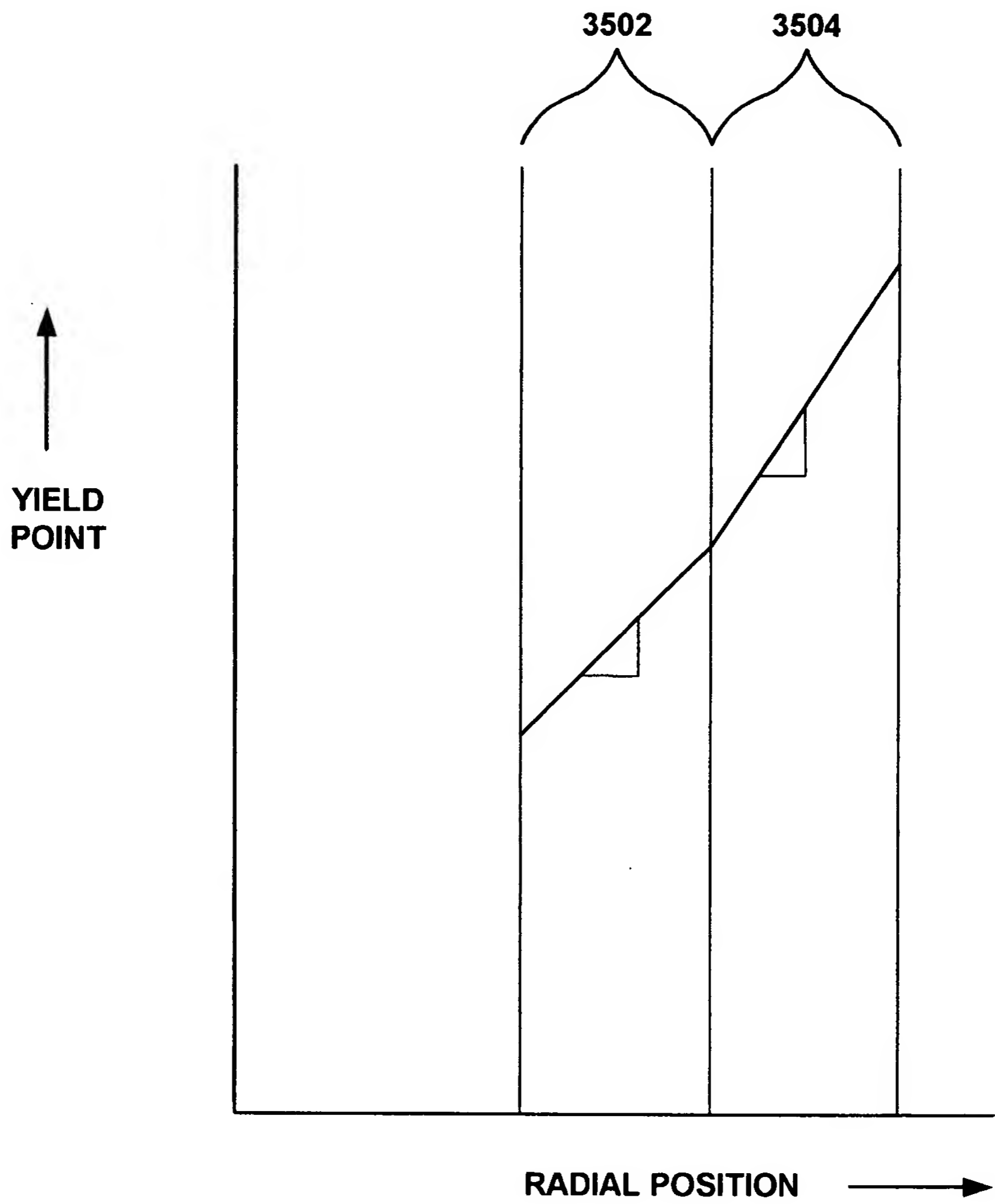


FIG. 35b

3600

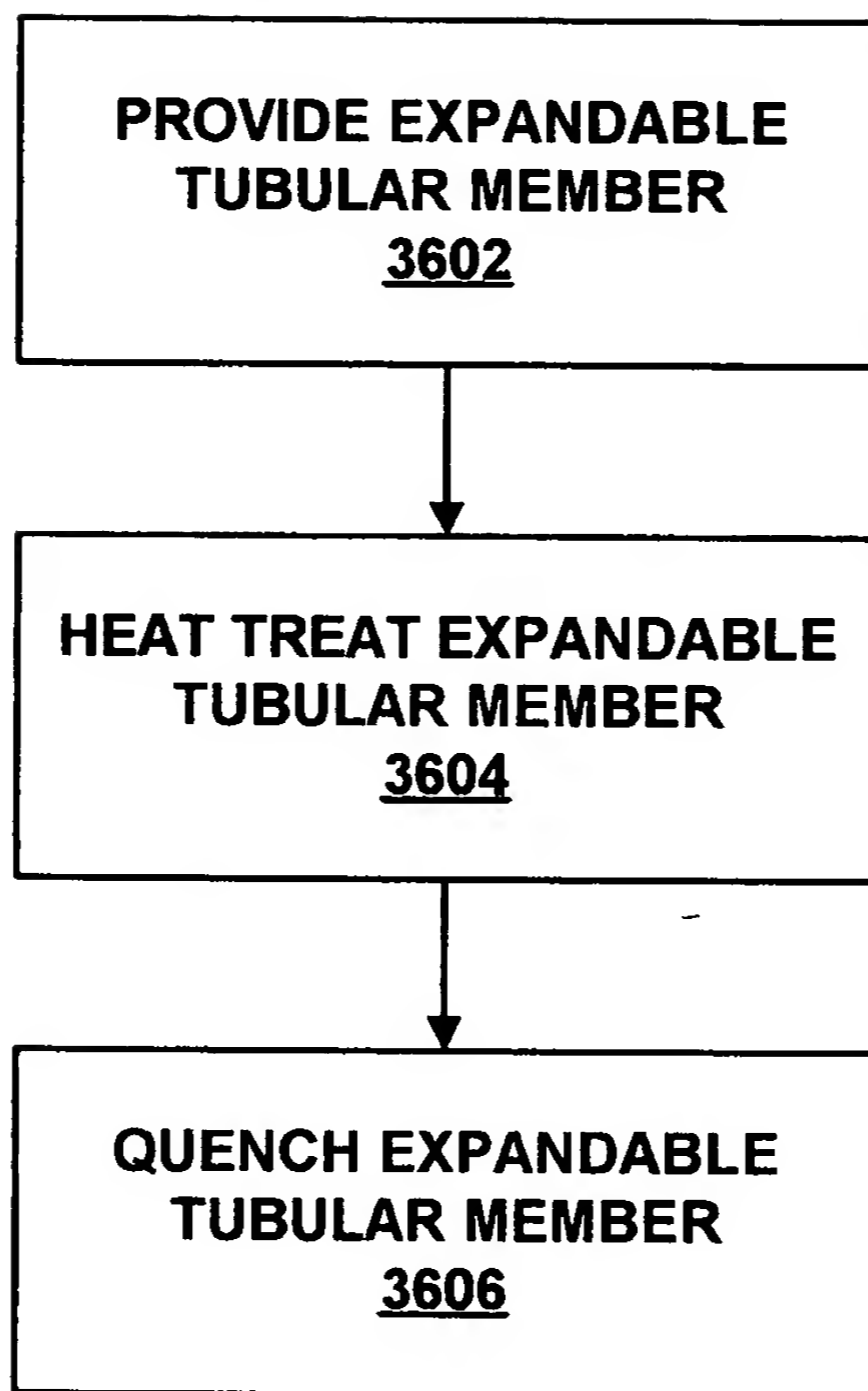
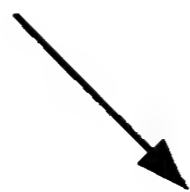
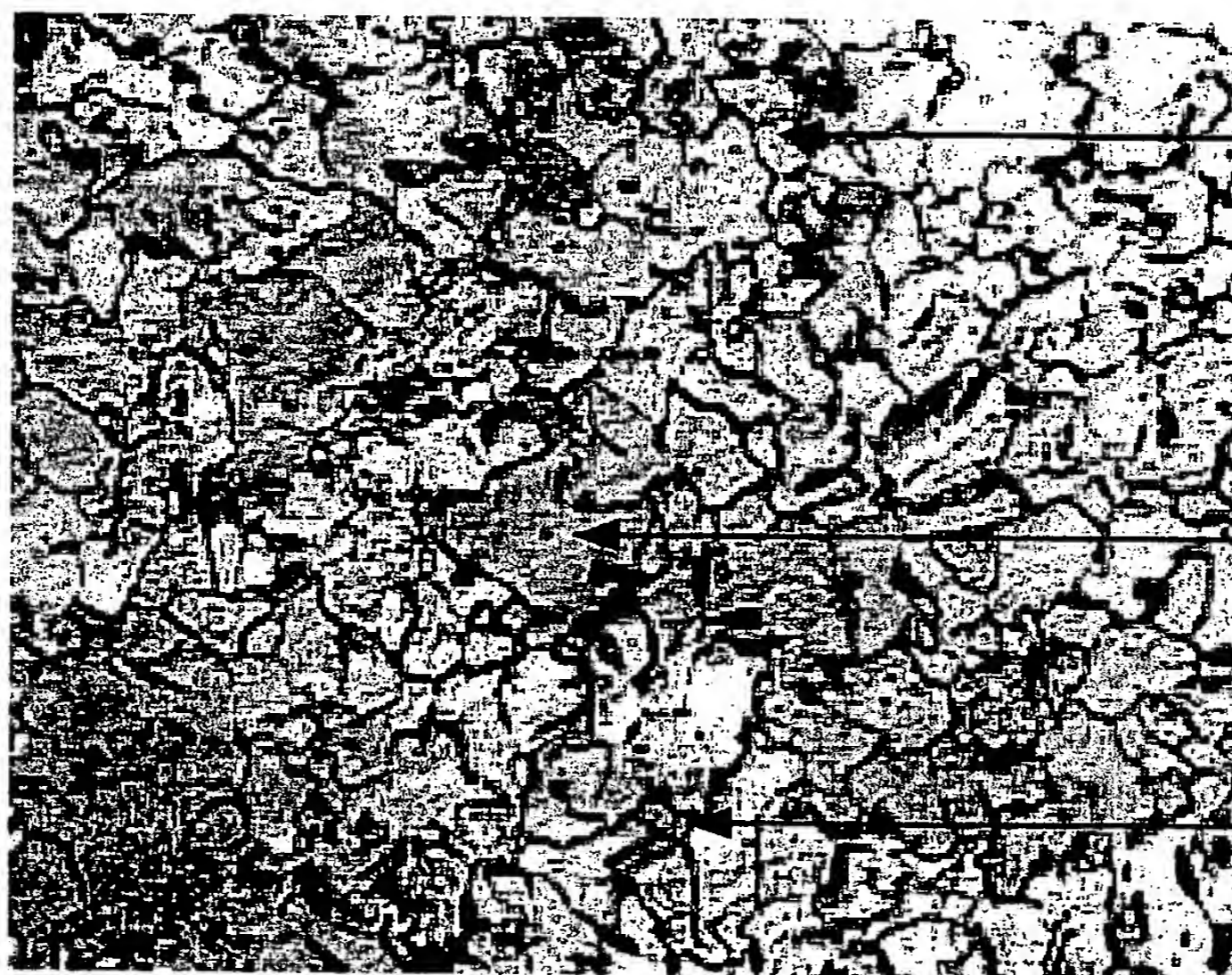


FIG. 36a

3602a



MARTENSITE

PEARLITE

V, Ni, Ti
CARBIDES

Fig. 36b

3602a

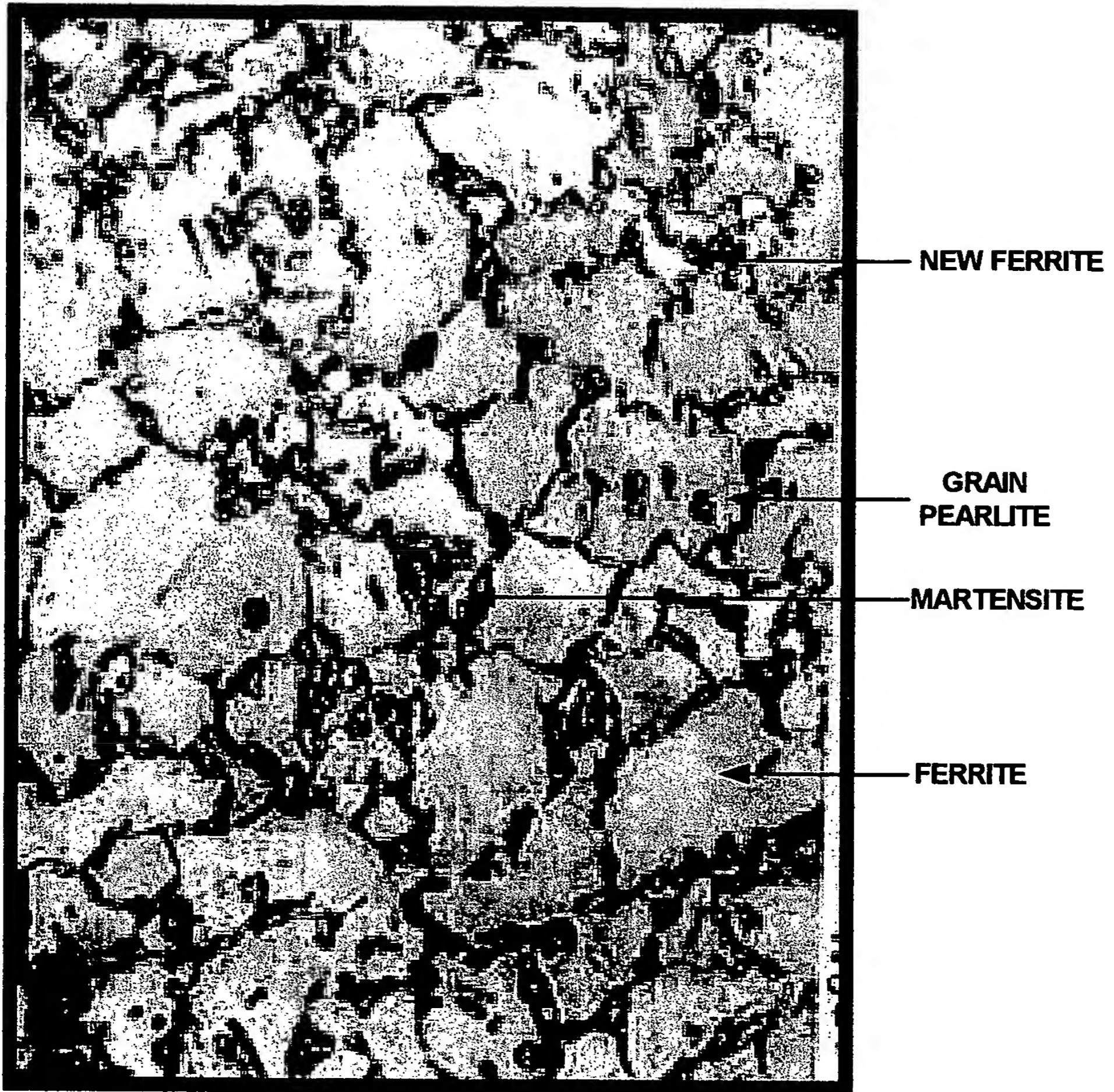


Fig. 36c

3700

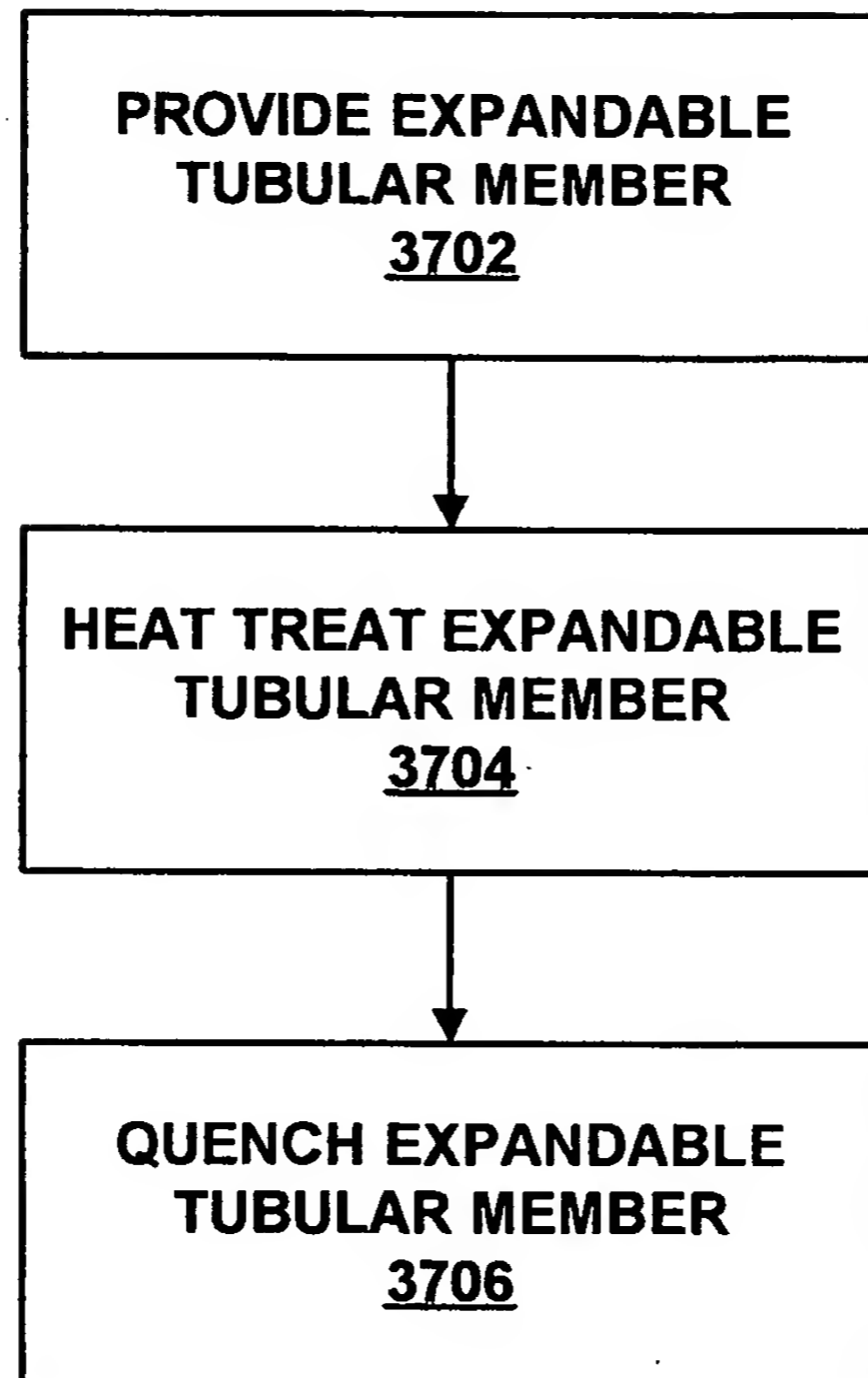
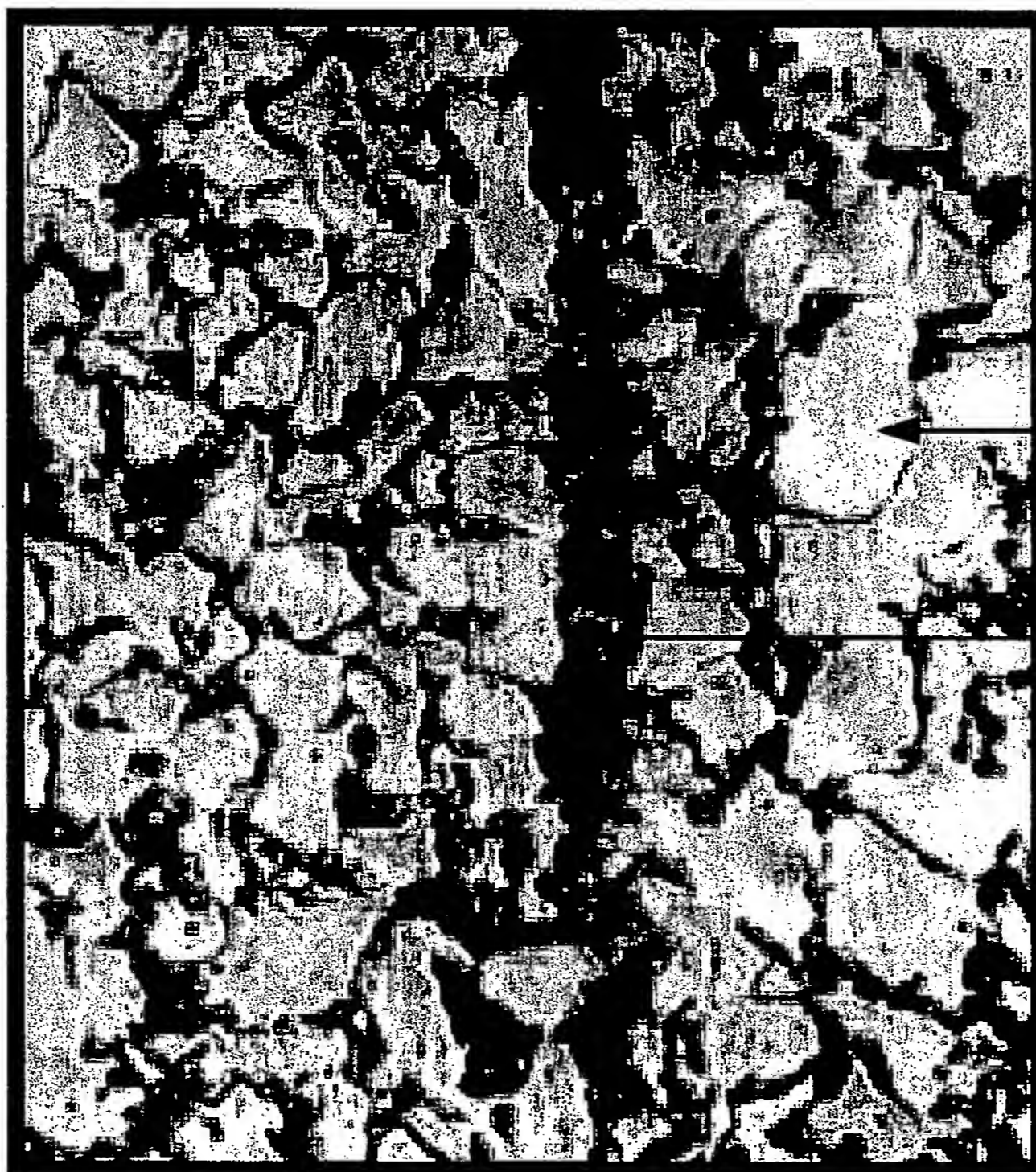


FIG. 37a

3702a



PEARLITE

PEARLITE
STRIATION

Fig. 37b

3702a



FERRITE

MARTENSITE

BAINITE

Fig. 37c

3800

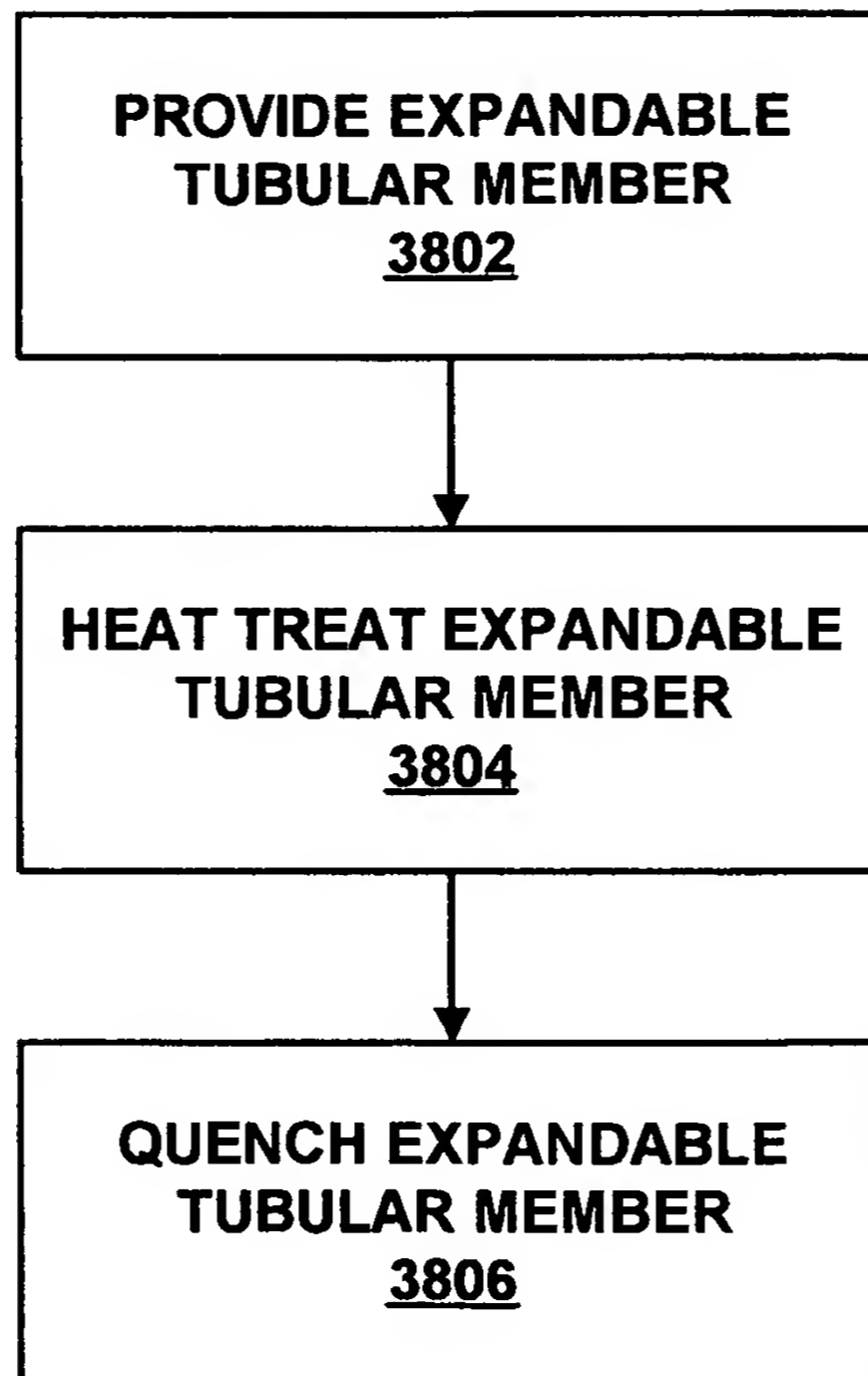


FIG. 38a

3802a



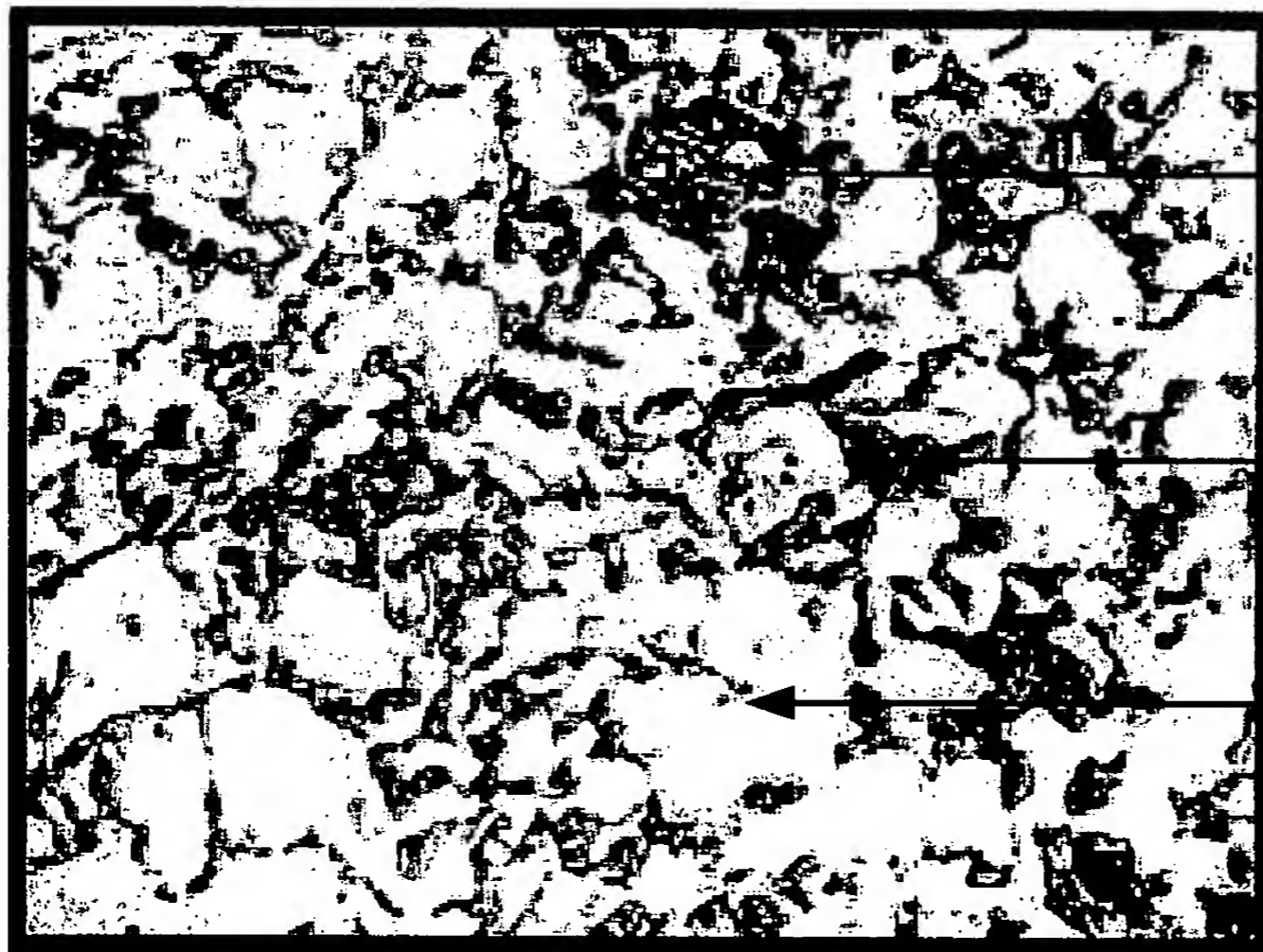
GRAIN PEARLITE

WIDMANSTATTEN
MARTENSITE

V, Ni, and Ti CARBIDES

Fig. 38b

3802a



BAINITE

PEARLITE

NEW FERRITE

Fig. 38c

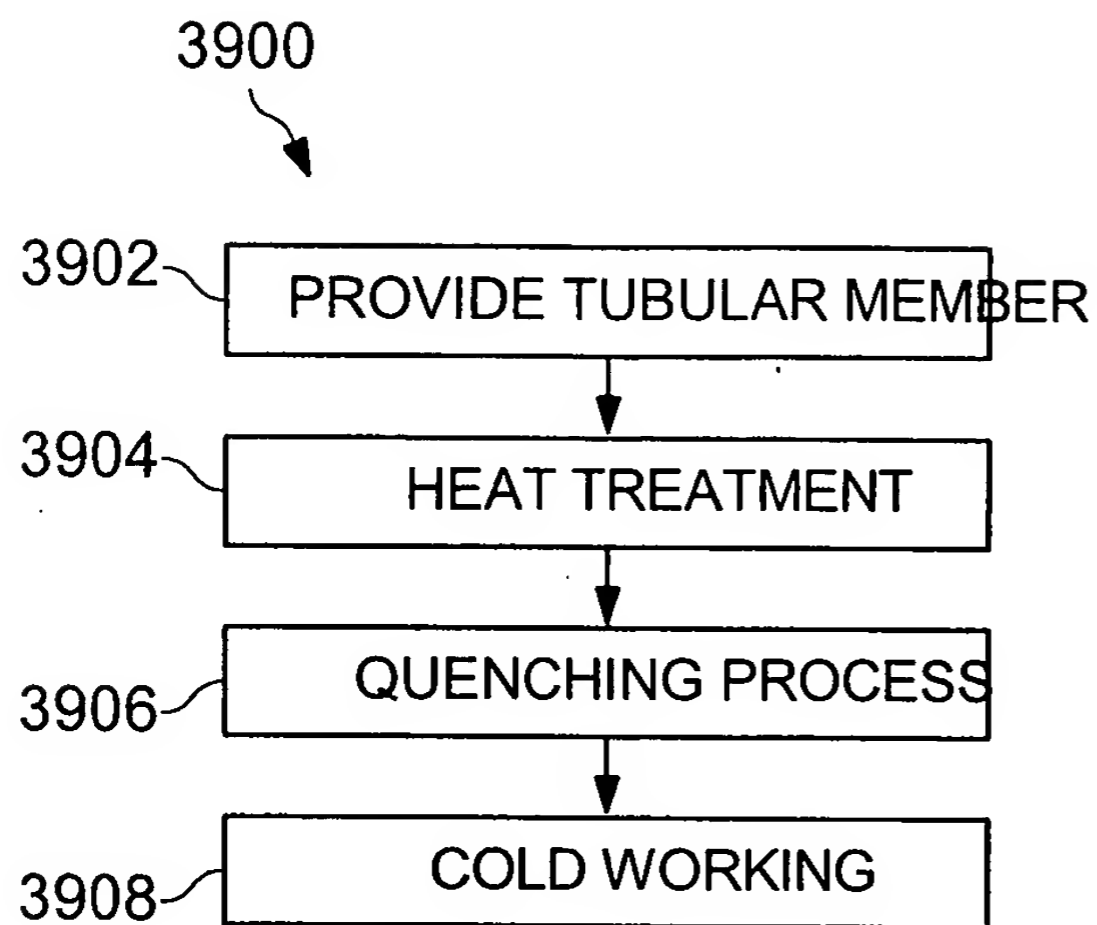


Fig. 39

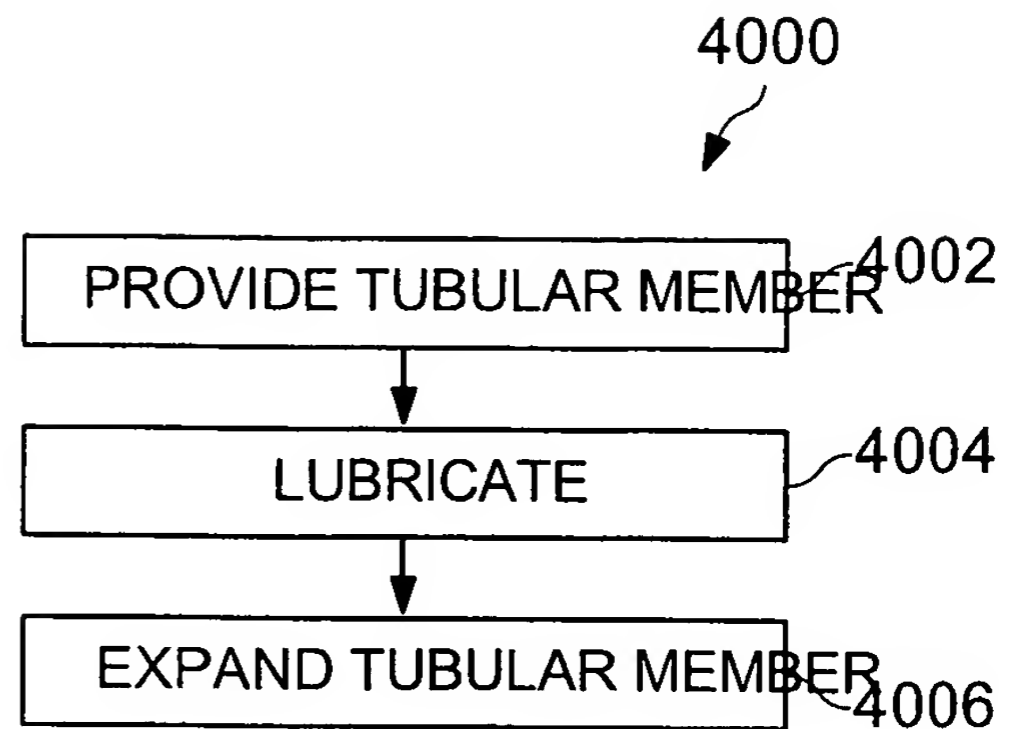


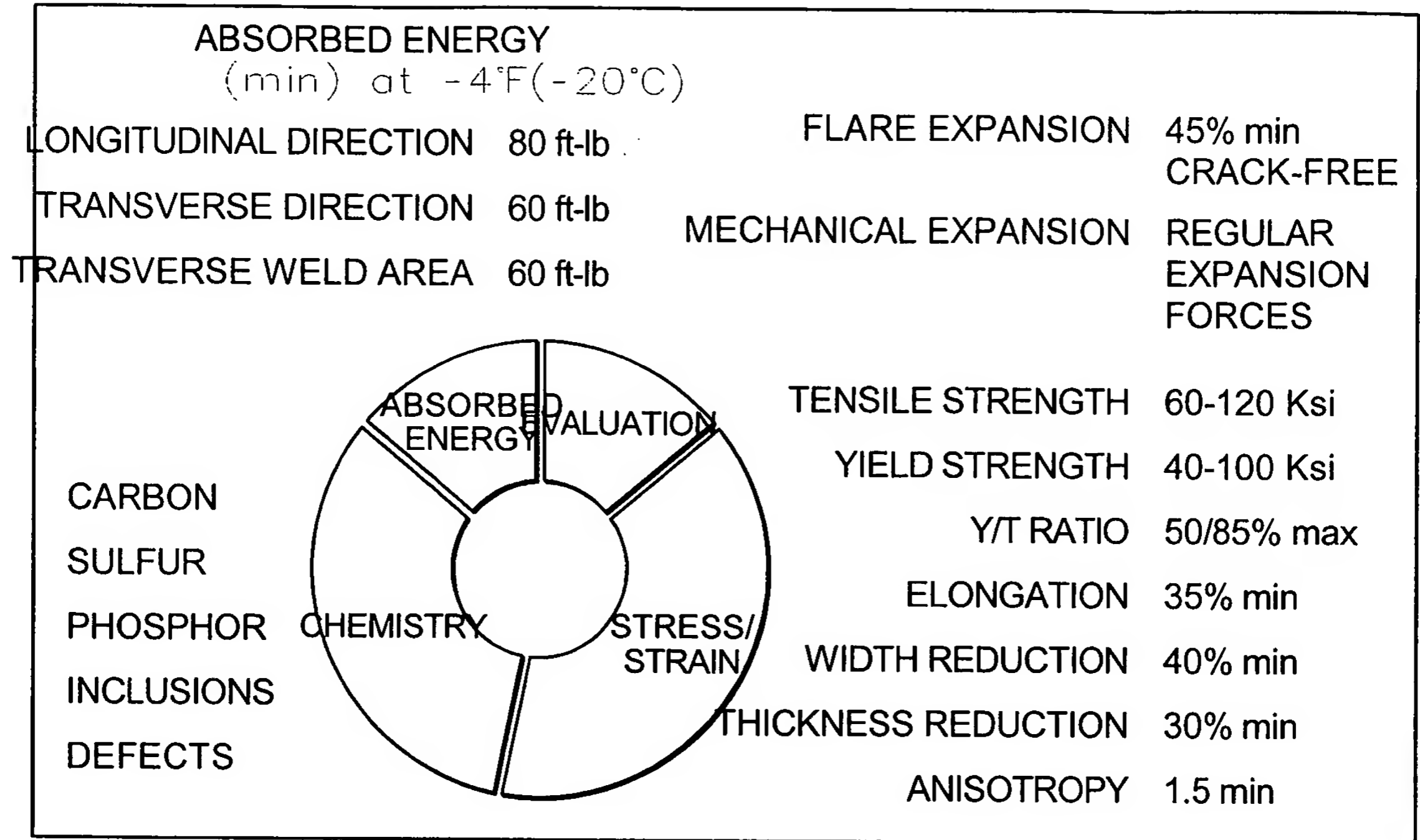
Fig. 40

- 4100
- 4102 STRESS-STRAIN PROPERTIES
 - Optimum combination of the strength and elongation
 - 4104 CHARPY V-NOTCH IMPACT VALUE
 - Impact tests on notched specimens are used to predict the likelihood of brittle fracture
 - 4106 STRESS RUPTURE (BURST, COLLAPSE)
 - Higher strength is better but decreased ductility/toughness with increased susceptibility to environmental cracking
 - 4108 STRAIN-HARDENING EXPONENT (N-VALUE)
 - Material with higher strain-hardening exponent can avoid failure during tube expansion
 - 4110 PLASTIC STRAIN RATIO (R OR LANKFORD-VALUE)
 - The ratio of the strains occurring in the width and thickness directions. In case greater than 1.0 will be more resistant to thinning and better suited to tubular expansion

Fig. 41

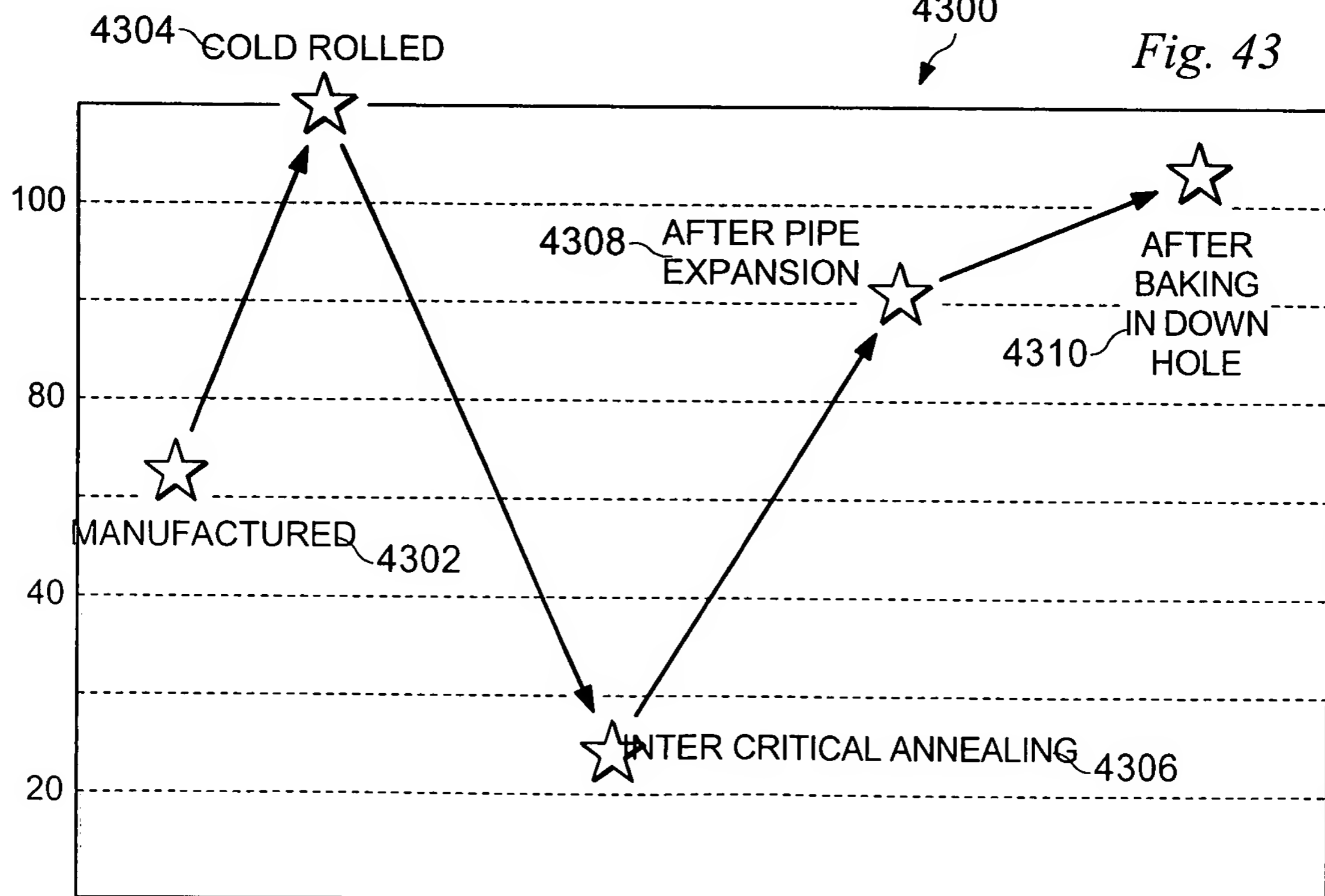
4200

Fig. 42



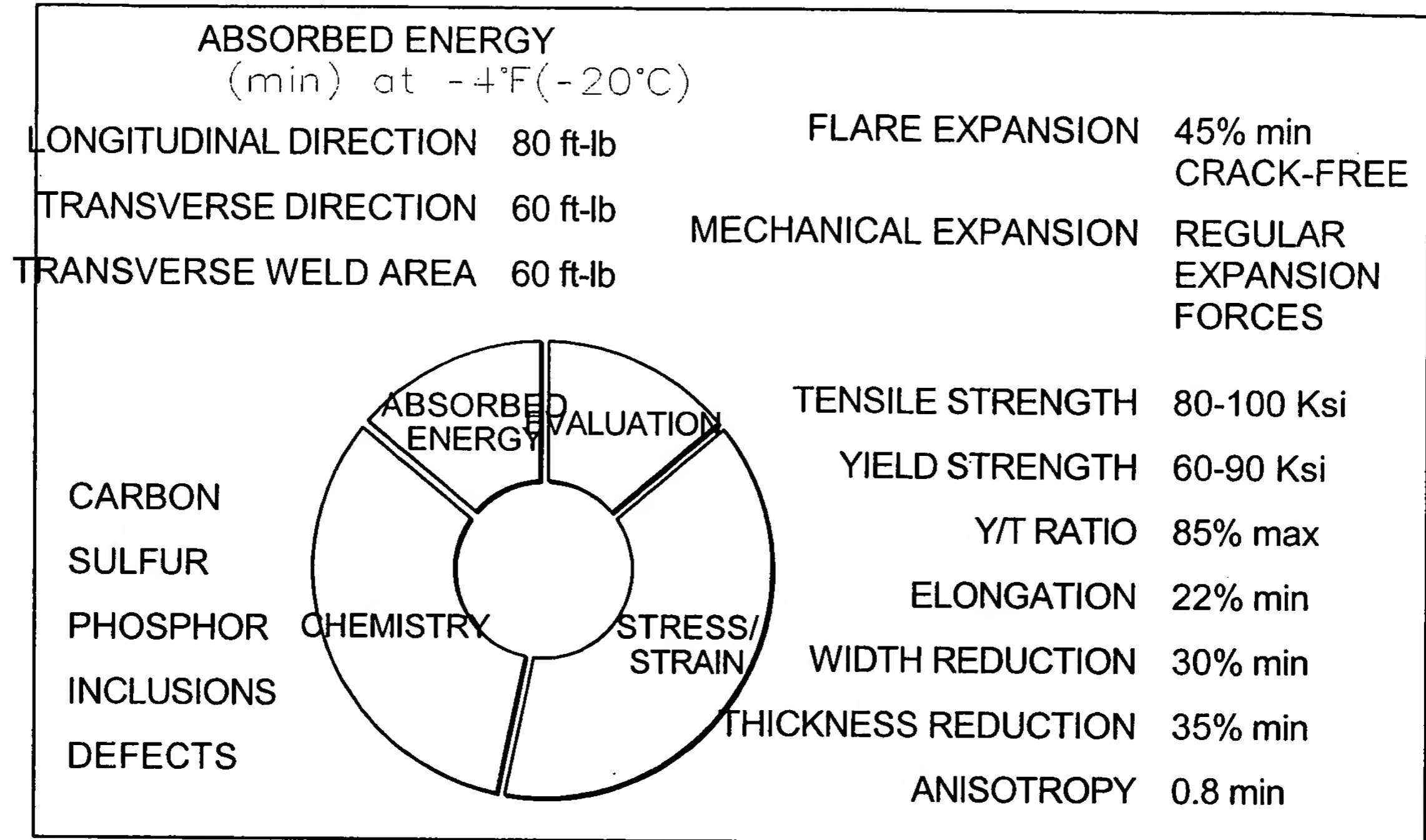
4300

Fig. 43



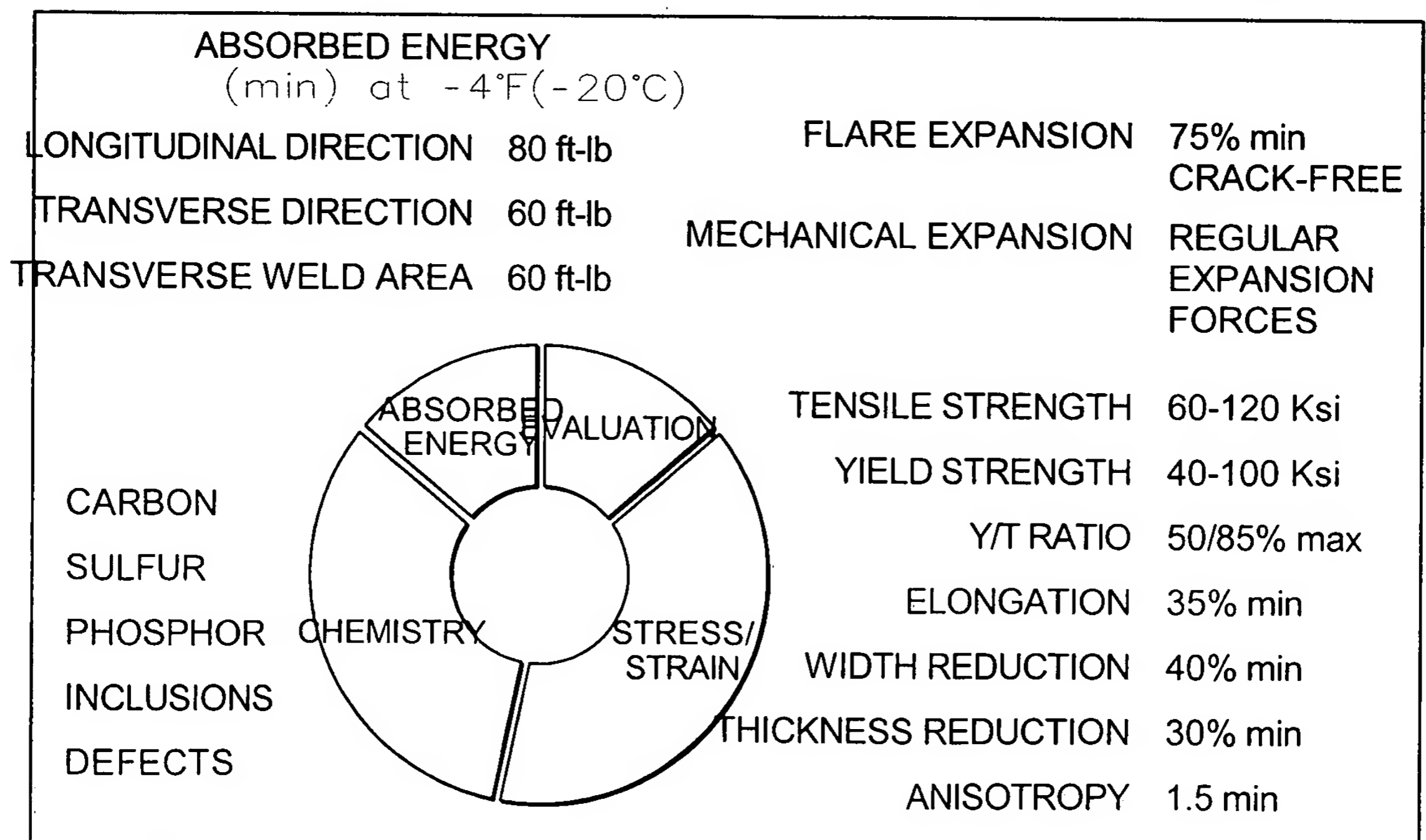
4400

Fig. 44



4500

Fig. 45



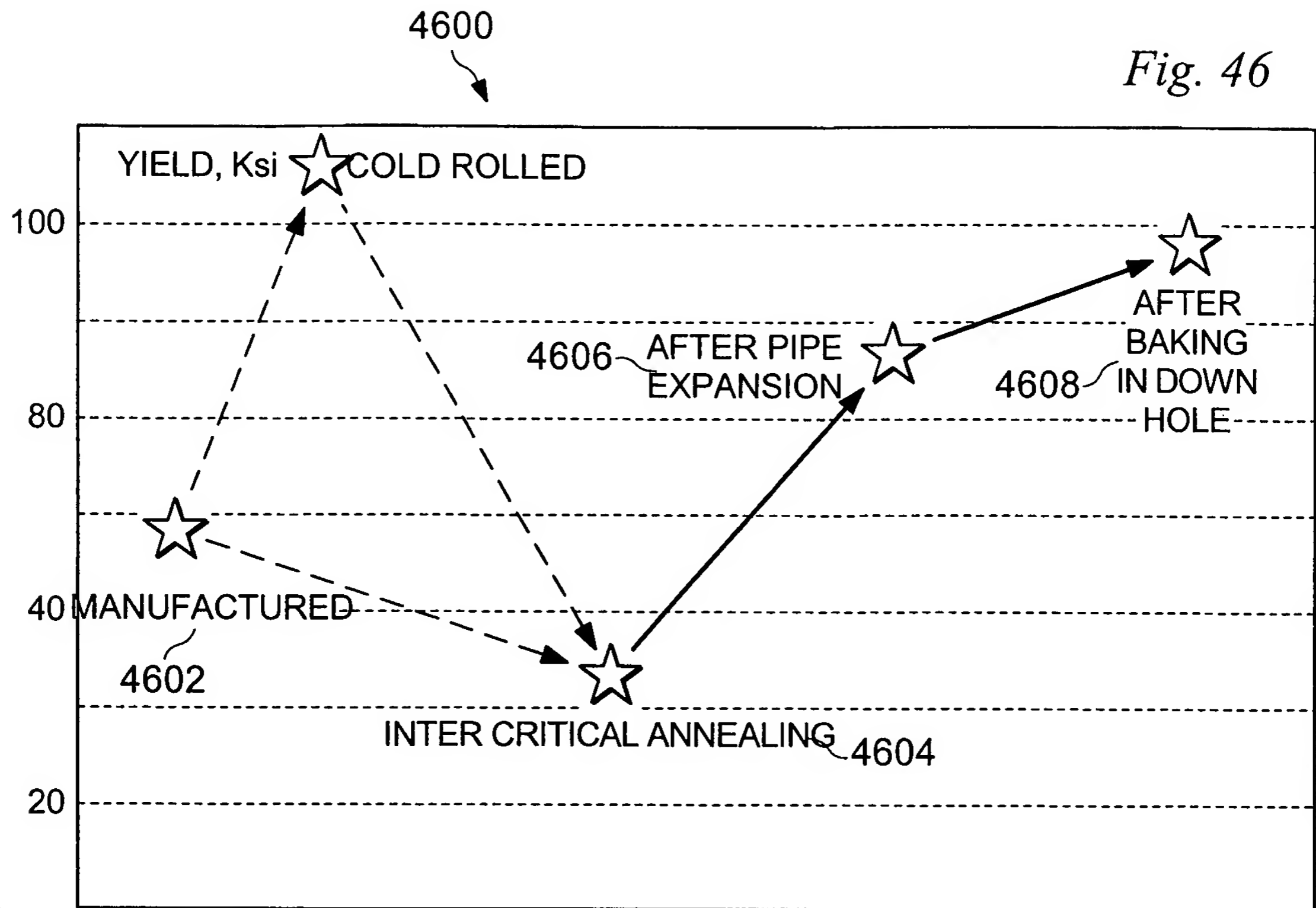


Fig. 47

4700

<ul style="list-style-type: none"> • NEW METALLURGY • WARM-REDUCING NEW MANUFACTURING PROCESS • HIGH STRENGTH AND EXCELLENT FORMABILITY • 20% HIGHER ELONGATION • HIGH R-VALUE (=STRAIN IN DIFFERENT DIRECTIONS) 			
	YIELD, Ksi	TENSILE Ksi	ELONGATION %
"HISTORY" PIPE	76.8	82.8	32
ERW PIPE	64.8	85.0	18

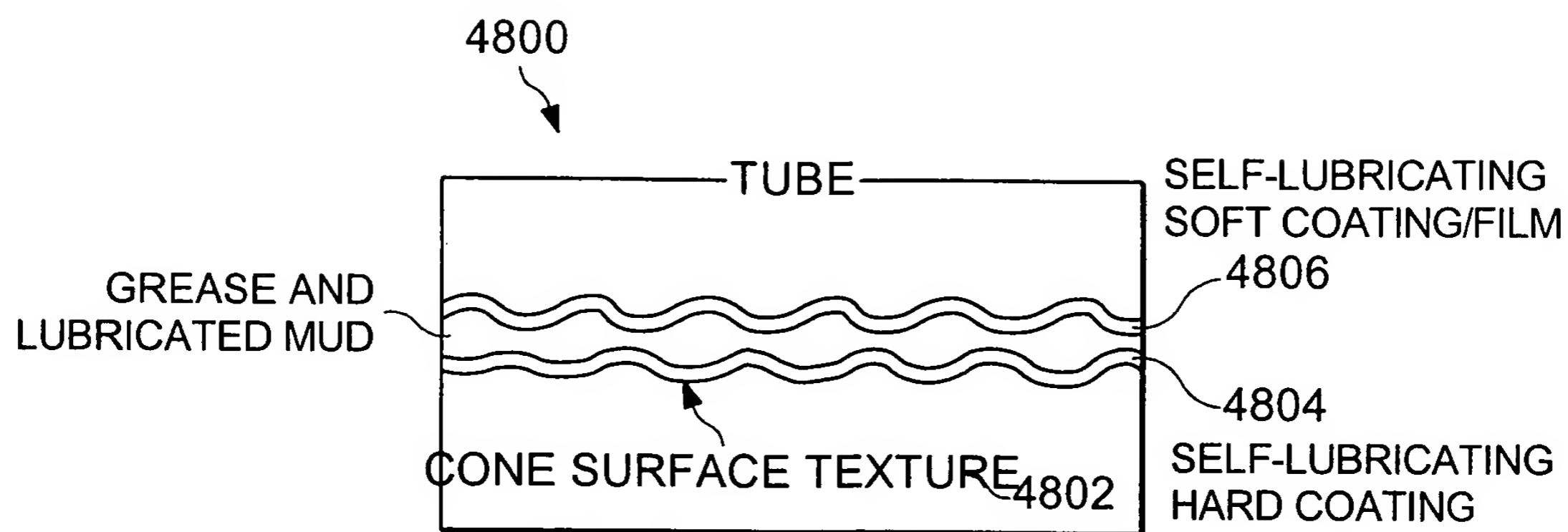


Fig. 48

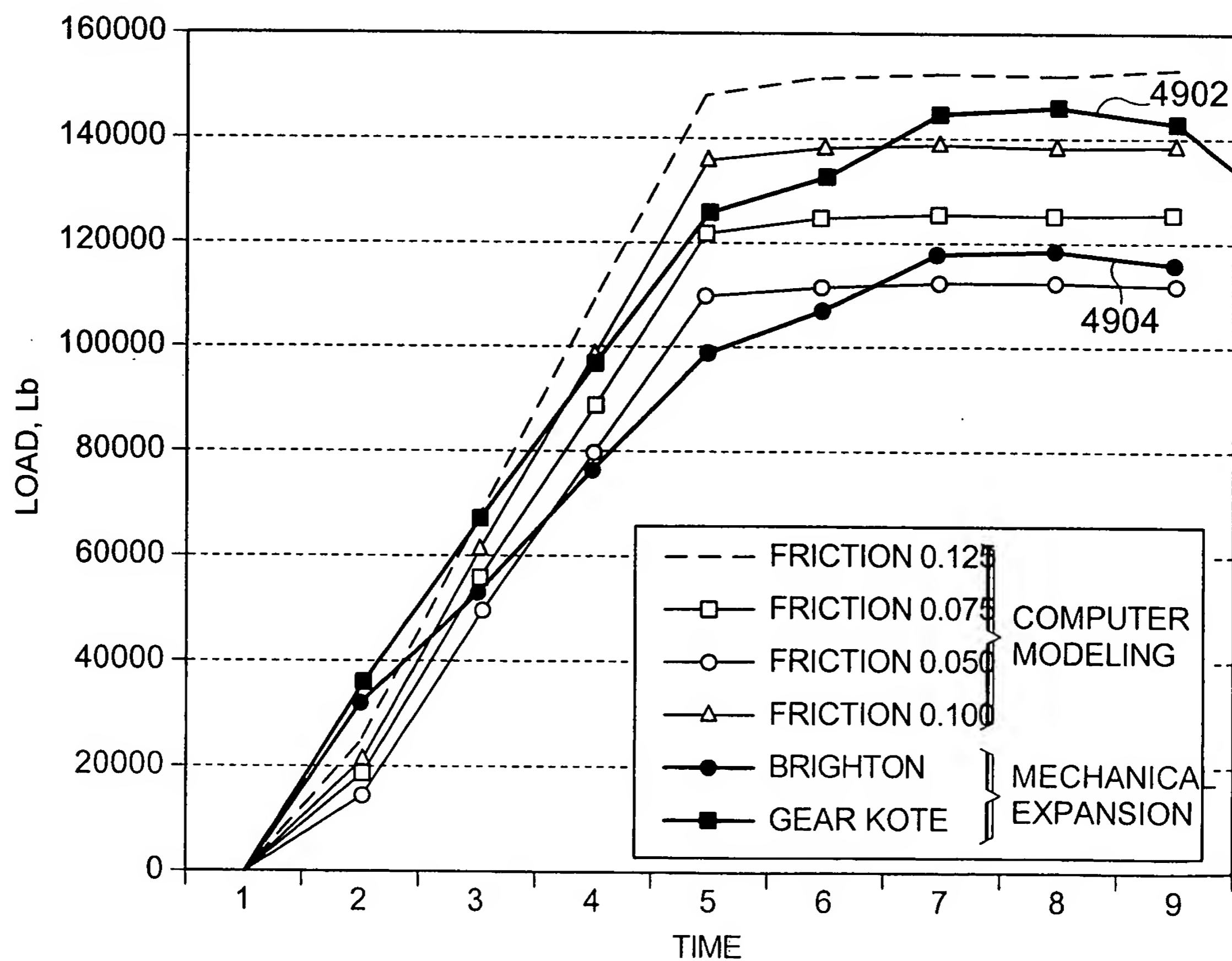


Fig. 49

Fig. 50a

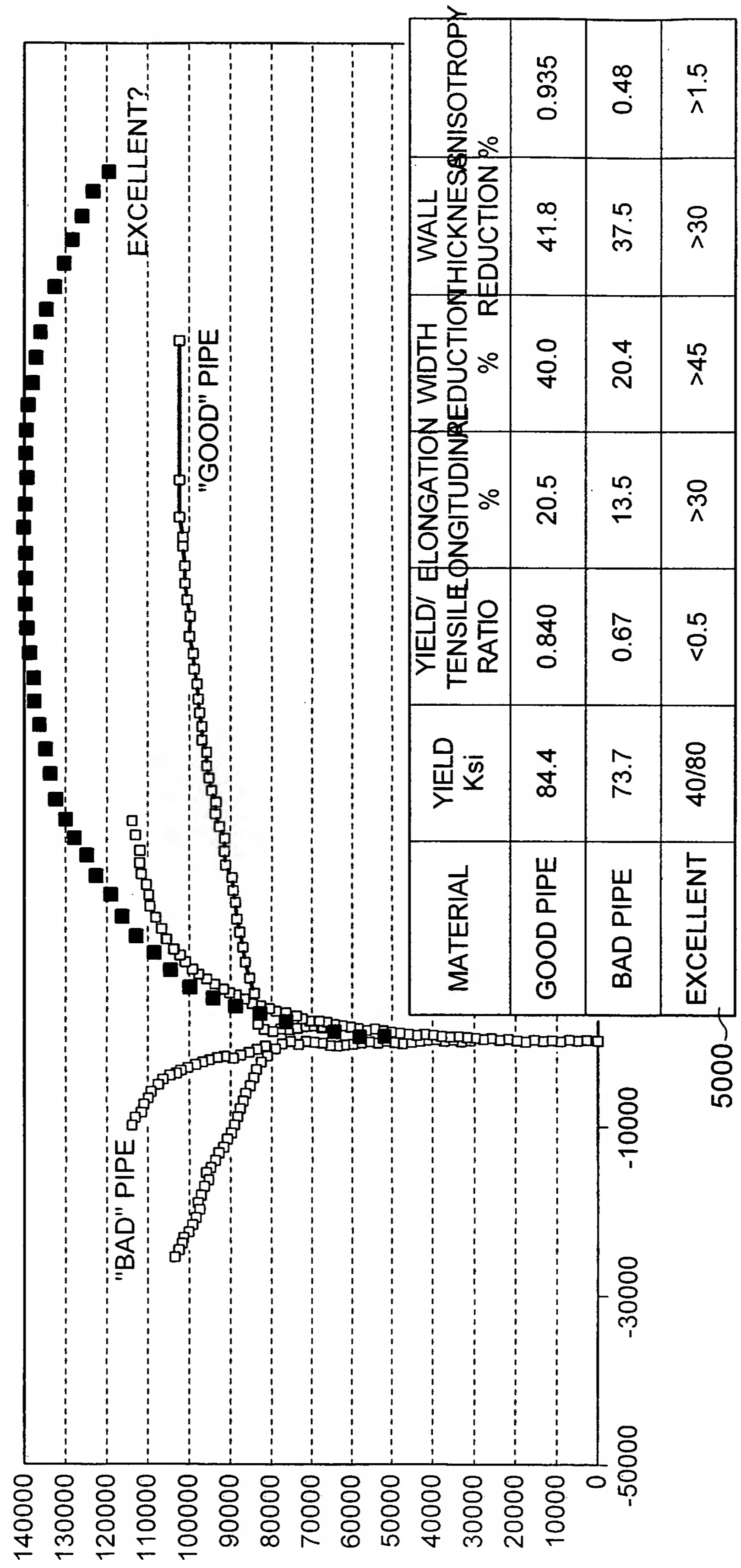


Fig. 50b

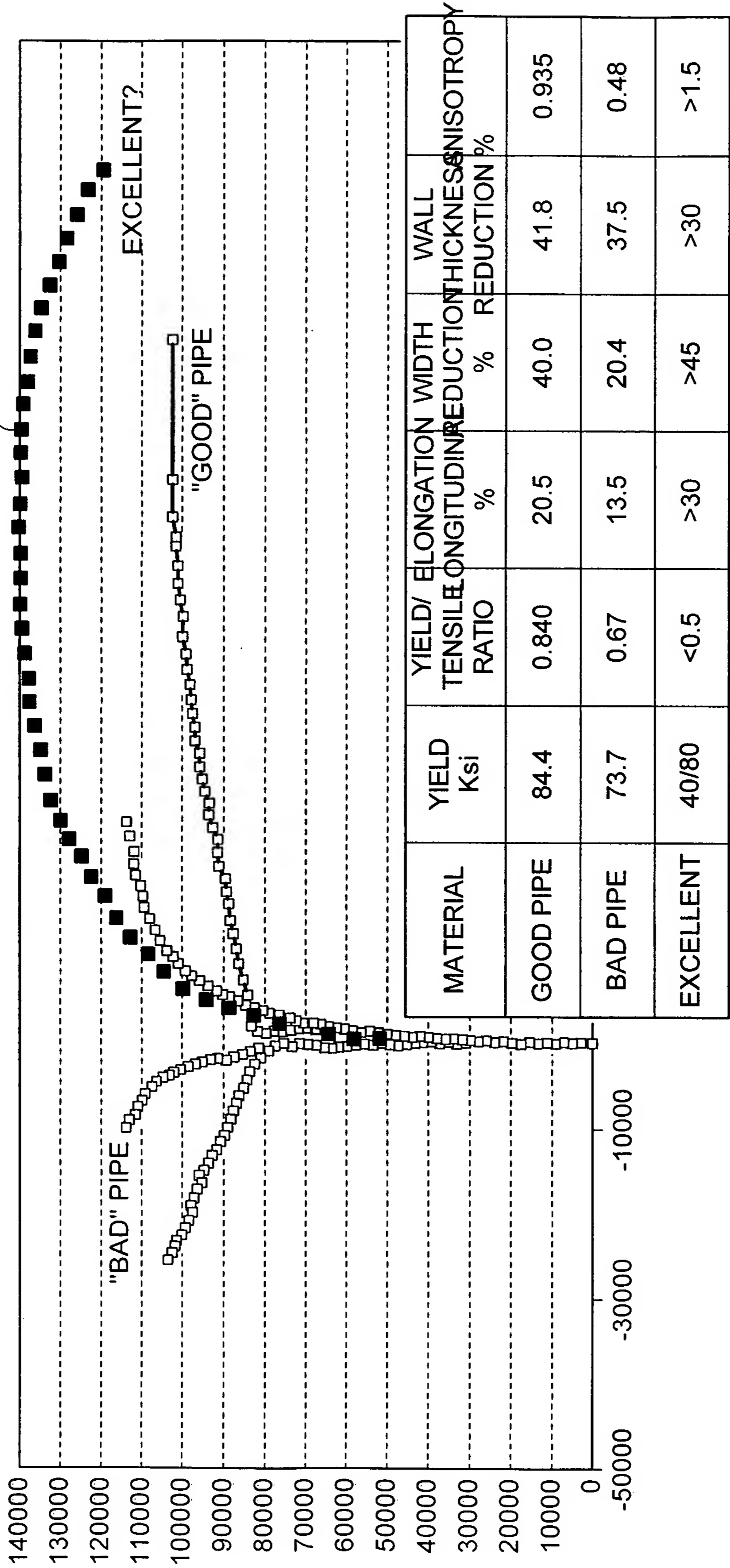
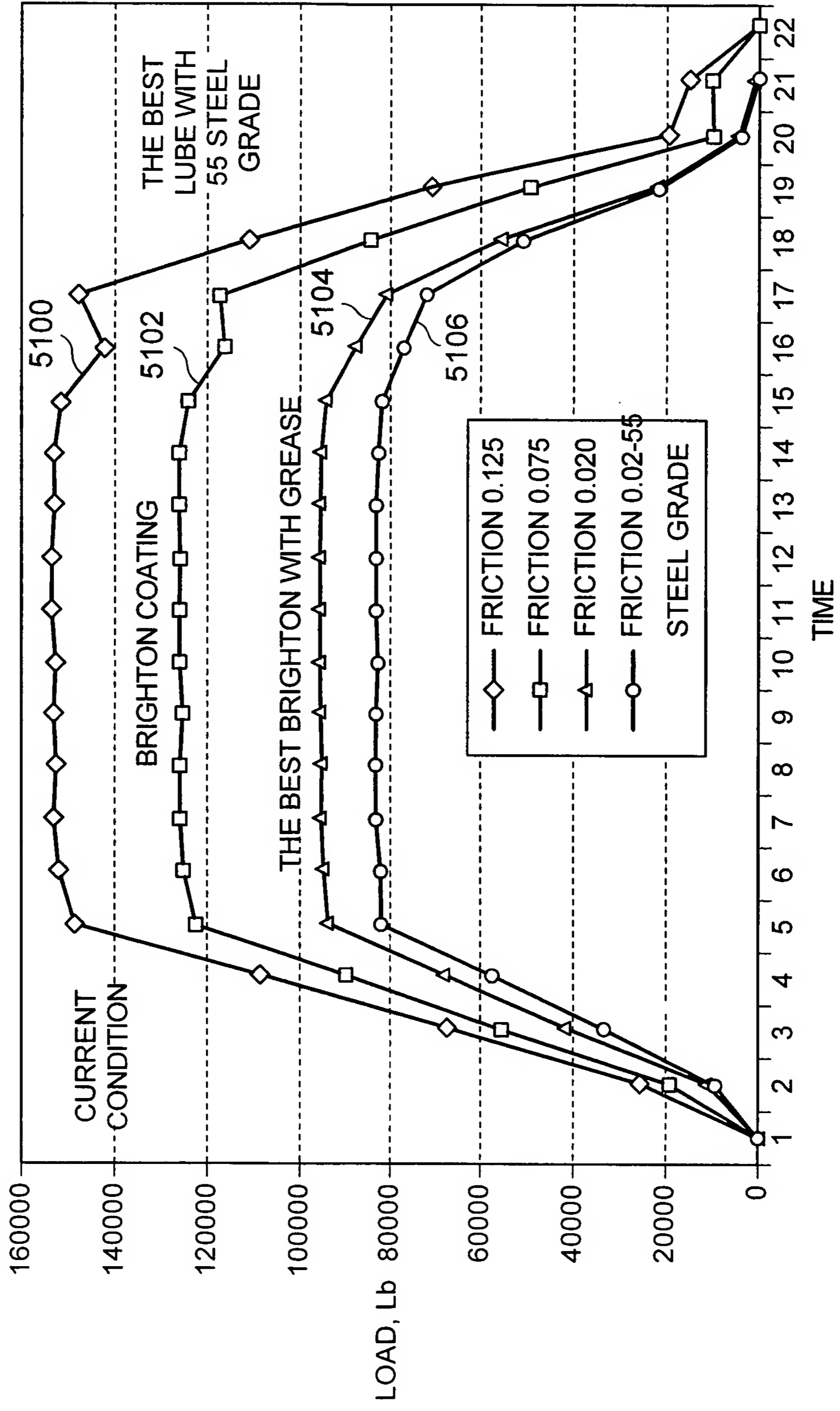


Fig. 51



		FRICTION	EXPANSION FORCE	WALL THICKNESS	D/t AFTER	COLLAPSE Ksi
5200	CURRENT 6" x .305 BSFL LUBE	0.125	145,900	0.305	24.8	2,379
5202	BRIGHTON LUBE APPLICATION	0.075	143,000	0.350	21.6	3,243
5204	BEST BRIGHTON WITH GREASE	0.020	149,900	0.450	16.8	5,837
5206	BEST LUBE WITH 55 Ksi STEEL	0.020	125,800	0.500	15.1	5,359
5208	BEST LUBE AND STEEL WITH 55 Ksi YIELD BEFORE AND 100 Ksi AFTER PIPE EXPANSION	0.020	126,800	0.500	15.1	8,443

Fig. 52

	SAMPLE	C	Mn	P	S	Si	Cu	Ni	Cr	V	Mo	Nb	Ti
5302	JFE-A*	.065	1.44	.010	.002	.24	.01	.01	.02	.04	.01	.03	.01
5304	JFE-B*	.180	1.28	.017	.004	.29	.01	.01	.03	.03	.03	.01	.01
5306	X52x0.37	.080	0.82	.006	.003	.30	.16	.05	0.5	.06	.01	.03	.01
5308	X52x0.52	.030	1.48	.014	.002	.16	.02	.01	.02	.06	.01	.03	.01

Fig. 53

5400 ↗

	5402	5404	5406	5408	5410	5412
	YIELD Ksi	YIELD RATIO	ELONGATION %	WIDTH REDUCTION %	WALL THICKNESS REDUCTION %	ANISOTROPY %
BEFORE	61.5	.62	17	26	47	.46
AFTER	74.7	.77	14	28	54	.44
CHANGE %	21.4	24	-18	7.7	14.5	-4.4

Fig. 54

5500 ↗

	5502	5504	5506	5508	5510	5512
	YIELD Ksi	YIELD RATIO	ELONGATION %	WIDTH REDUCTION %	WALL THICKNESS REDUCTION %	ANISOTROPY %
BEFORE	61.9	.6	12	18	15	1.24
AFTER	105	.75	4	13	14	.94
CHANGE %	-70	-25	-67	27.8	6.7	75

Fig. 55

5600

	5602 YIELD Ksi	5604 YIELD RATIO	5606 ELONGATION %	5608 WIDTH REDUCTION %	5610 WALL THICKNESS REDUCTION %	5612 ANISOTROPY %
BEFORE	64.9	.78	20	47	59	.72
AFTER	71.5	.80	14	41	58	.60
CHANGE %	10.2	2.6	-30	-13	-1.7	-16.7

Fig. 56

5700

	5702 YIELD Ksi	5704 YIELD RATIO	5706 ELONGATION %	5708 WIDTH REDUCTION %	5710 WALL THICKNESS REDUCTION %	5712 ANISOTROPY %
BEFORE	46.9	.69	53	-52	55	.93
16% EXPANSION	65.9	.83	17	42	51	.78
24% EXPANSION	68.5	.83	5	44	54	.76
CHANGE %	46	-20	91	15	2	18

Fig. 57

5800 ↗

	5802	5804	5806	5808	5810	5812
	YIELD Ksi	YIELD RATIO	ELONGATION %	WIDTH REDUCTION %	WALL THICKNESS REDUCTION %	ANISOTROPY %
BEFORE	47.7	.69	23	46	53	0.81
AFTER	65.9	.83	17	42	51	0.78
CHANGE %	38	20	11	9	4	4

Fig. 58

5900 ↗

	5902	5904	5906	5908	5910	5912
	YIELD Ksi	YIELD RATIO	ELONGATION %	WIDTH REDUCTION %	WALL THICKNESS REDUCTION %	ANISOTROPY %
BEFORE	47.7	.69	23	46	53	0.81
AFTER	62.3	.71	12	40	52	.71
CHANGE %	31	14	48	13	2	12

Fig. 59

	6002 YIELD Ksi	6004 YIELD RATIO	6006 ELONGATION %	6008 WIDTH REDUCTION %	6010 WALL THICKNESS REDUCTION %	6012 ANISOTROPY %
BEFORE	57.8	.71	44	43	46	.93
16% EXPANSION	74.4	.84	16	38	42	.87
24% EXPANSION	79.8	.86	20	36	42	.81
CHANGE %	38	-21	55	16	9	13

Fig. 60

	6102 YIELD Ksi	6104 YIELD RATIO	6106 ELONGATION %	6108 WIDTH REDUCTION %	6110 WALL THICKNESS REDUCTION %	6112 ANISOTROPY %
BEFORE	56.4	.66	20	-39	-45	.83
AFTER	74.8	.83	14	33	41	.75
CHANGE %	33	26	30	15	9	10

Fig. 61

6200

	6202	6204	6206	6208	6210	6212
	YIELD Ksi	YIELD RATIO	ELONGATION %	WIDTH REDUCTION %	WALL THICKNESS REDUCTION %	ANISOTROPY %
BEFORE	56.4	.66	20	-39	-45	.83
AFTER	79.6	.84	12	31	38	.79
CHANGE %	41	27	40	21	16	5

Fig. 62

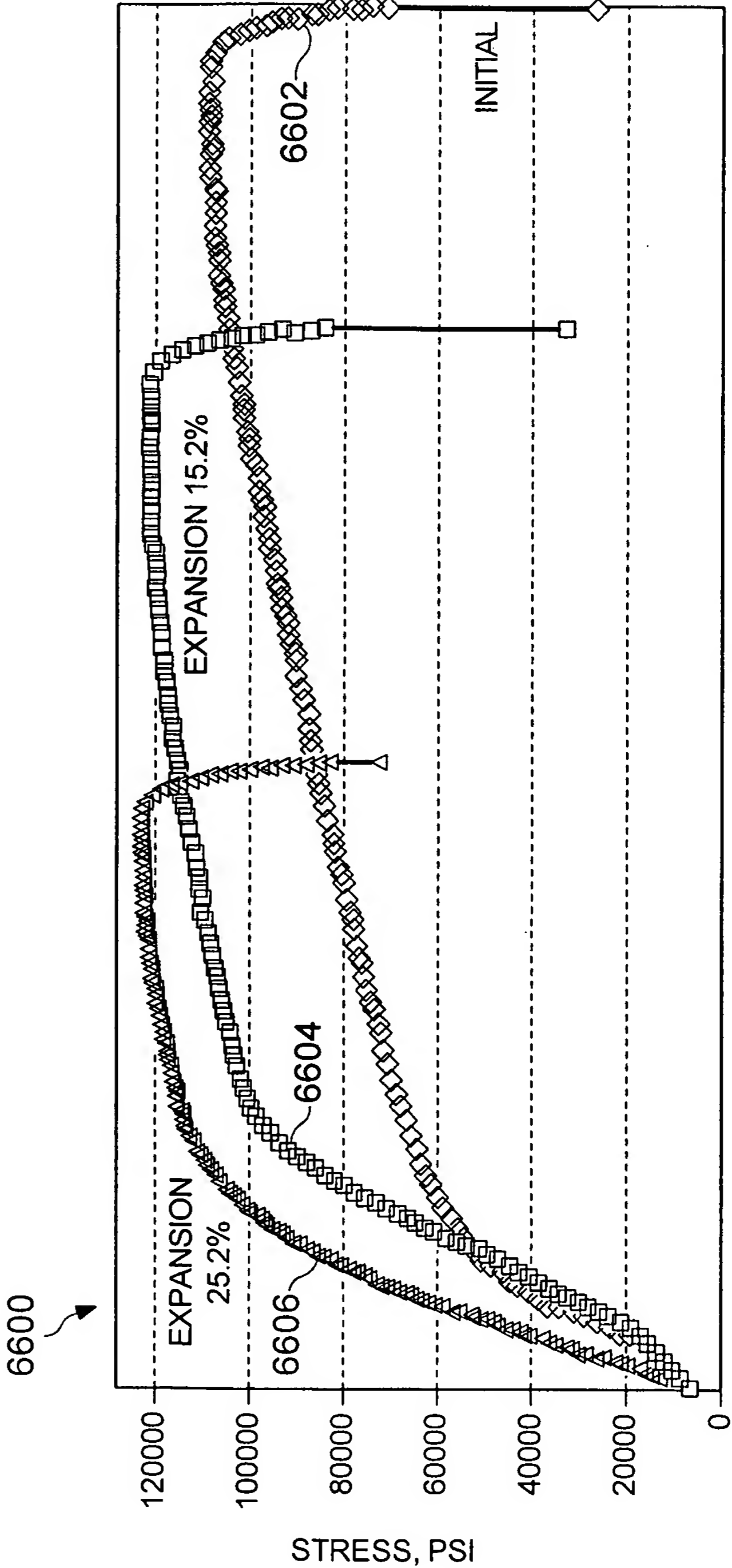
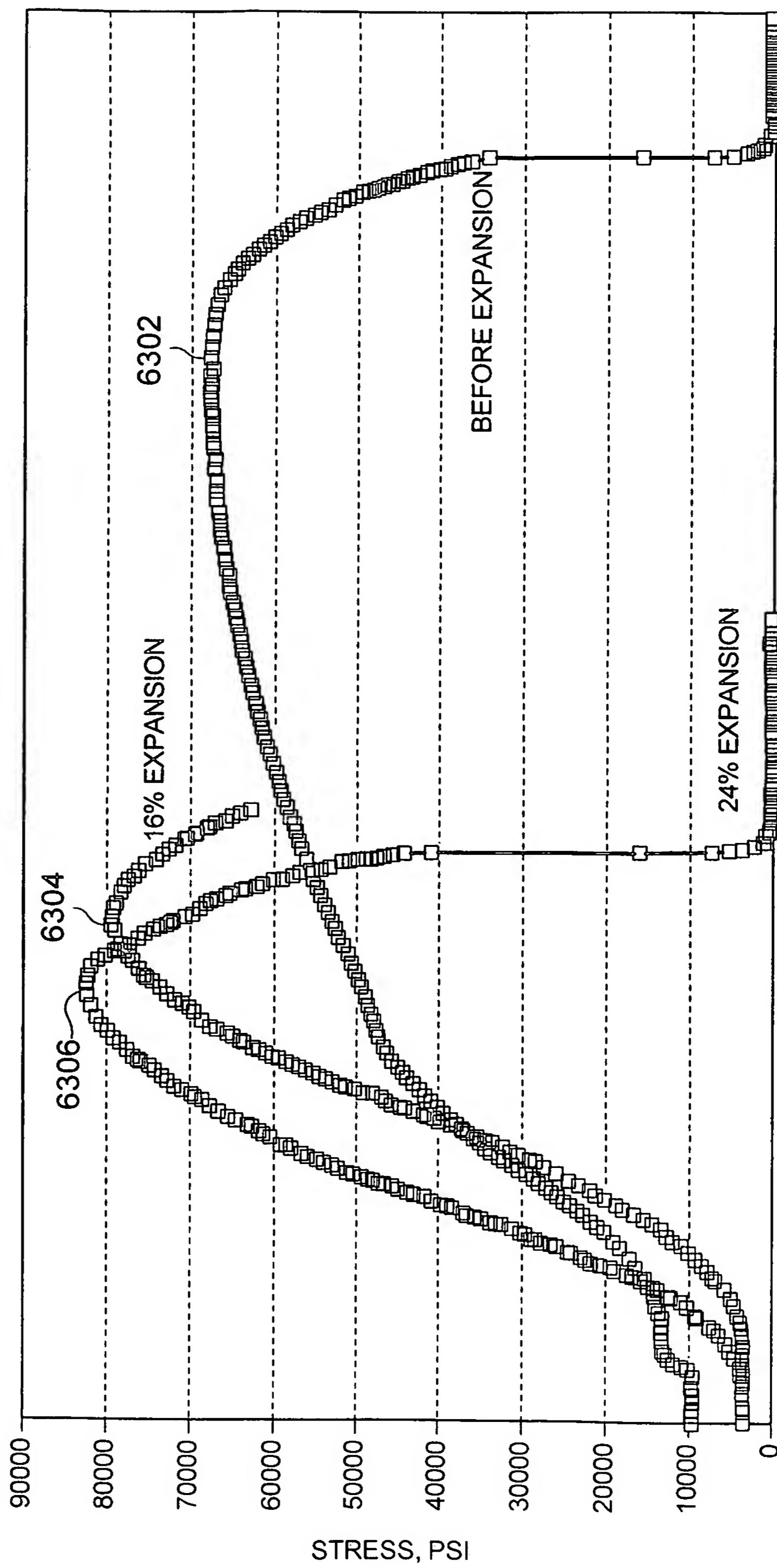


Fig. 66

6300 ↗

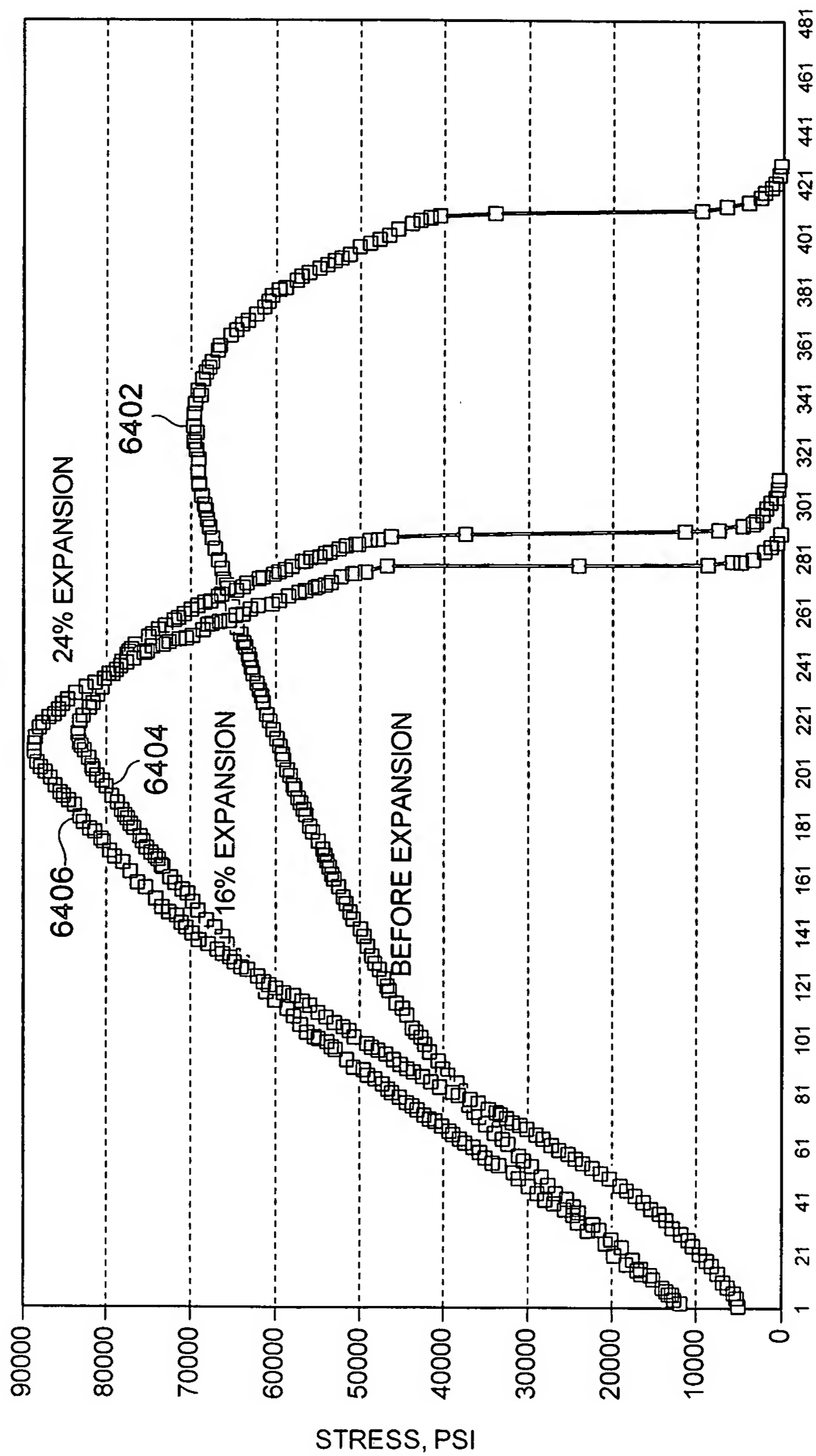
Fig. 63



1 20 39 58 77 96 115134153172191210229248267286305324343362381400419438457476495514533552571590609628647666685704723742761780799818837

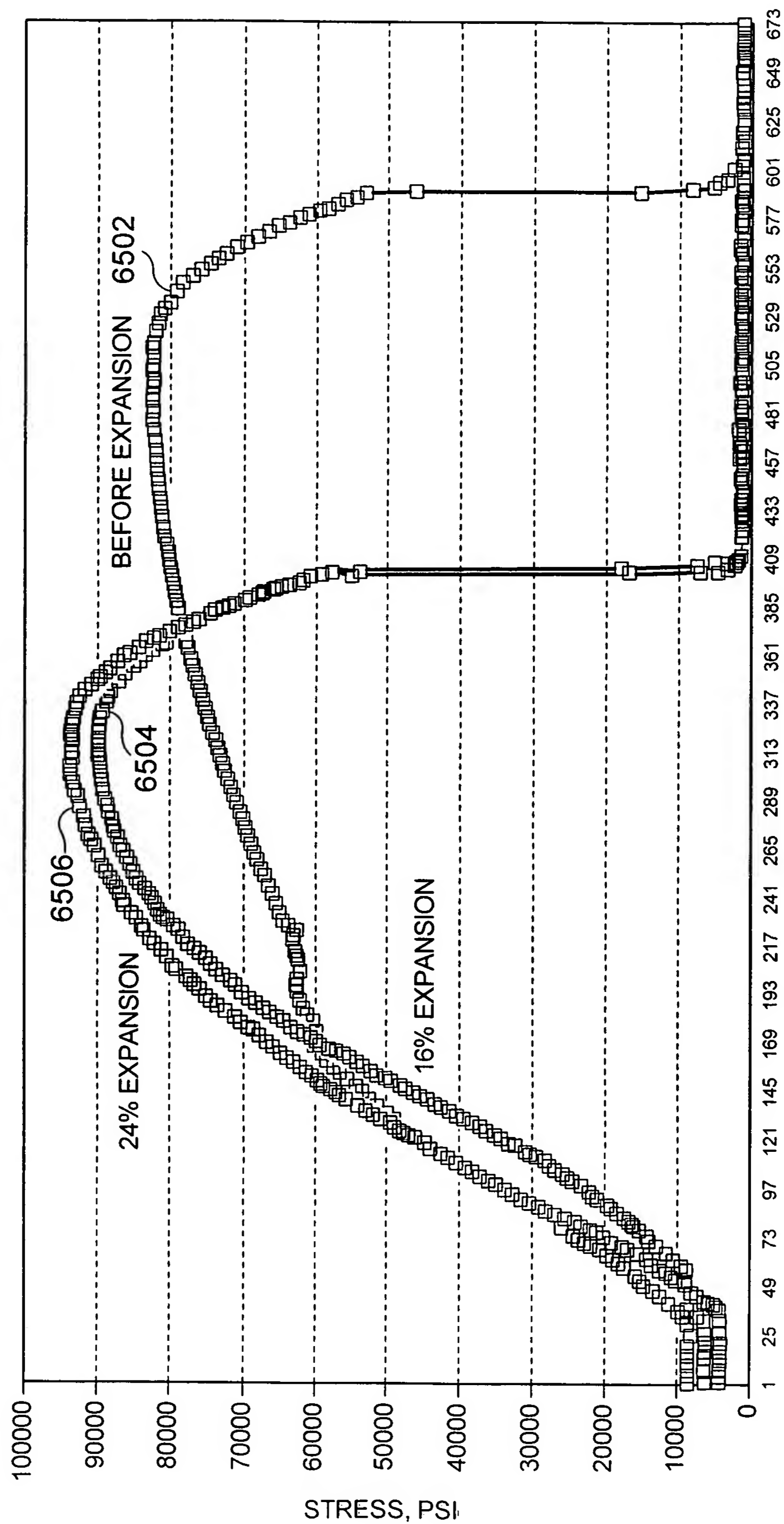
6400

Fig. 64



6500 ↗

Fig. 65



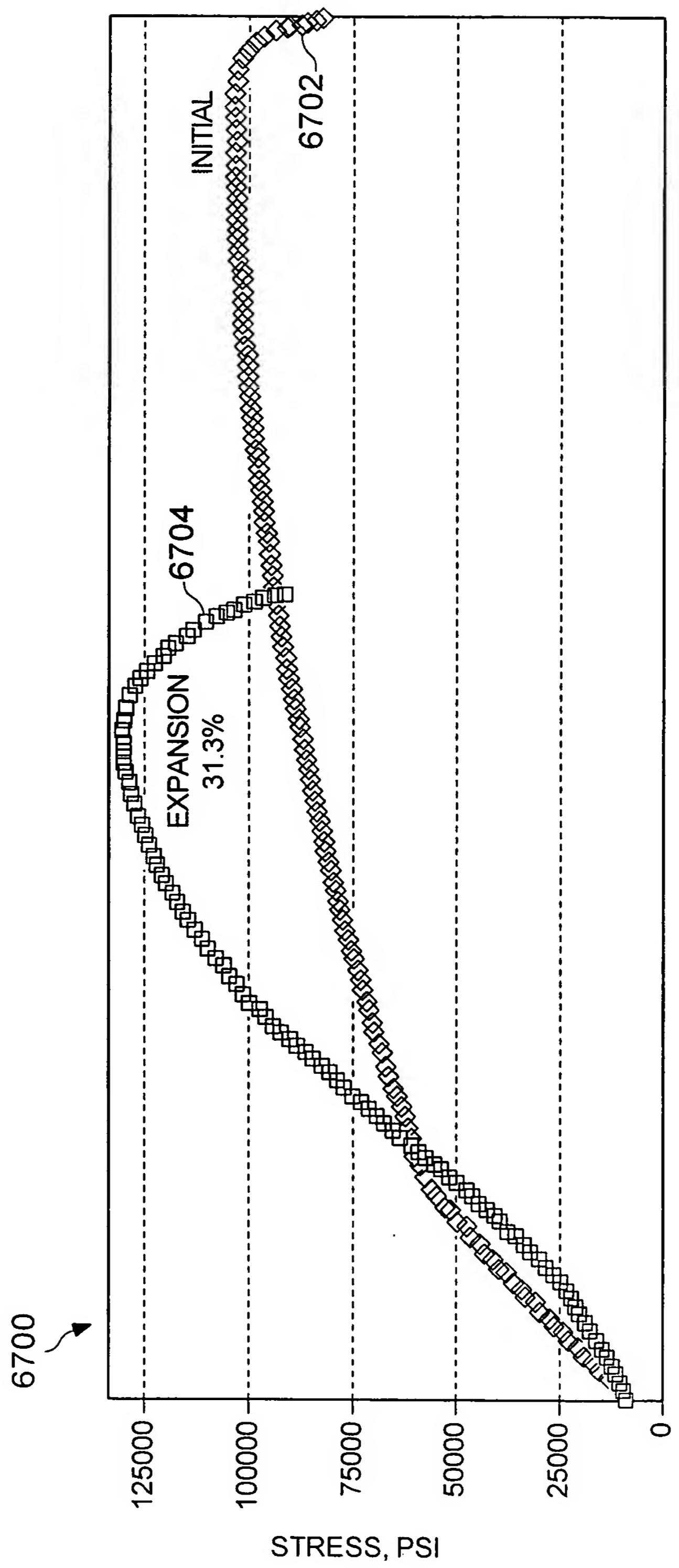


Fig. 67

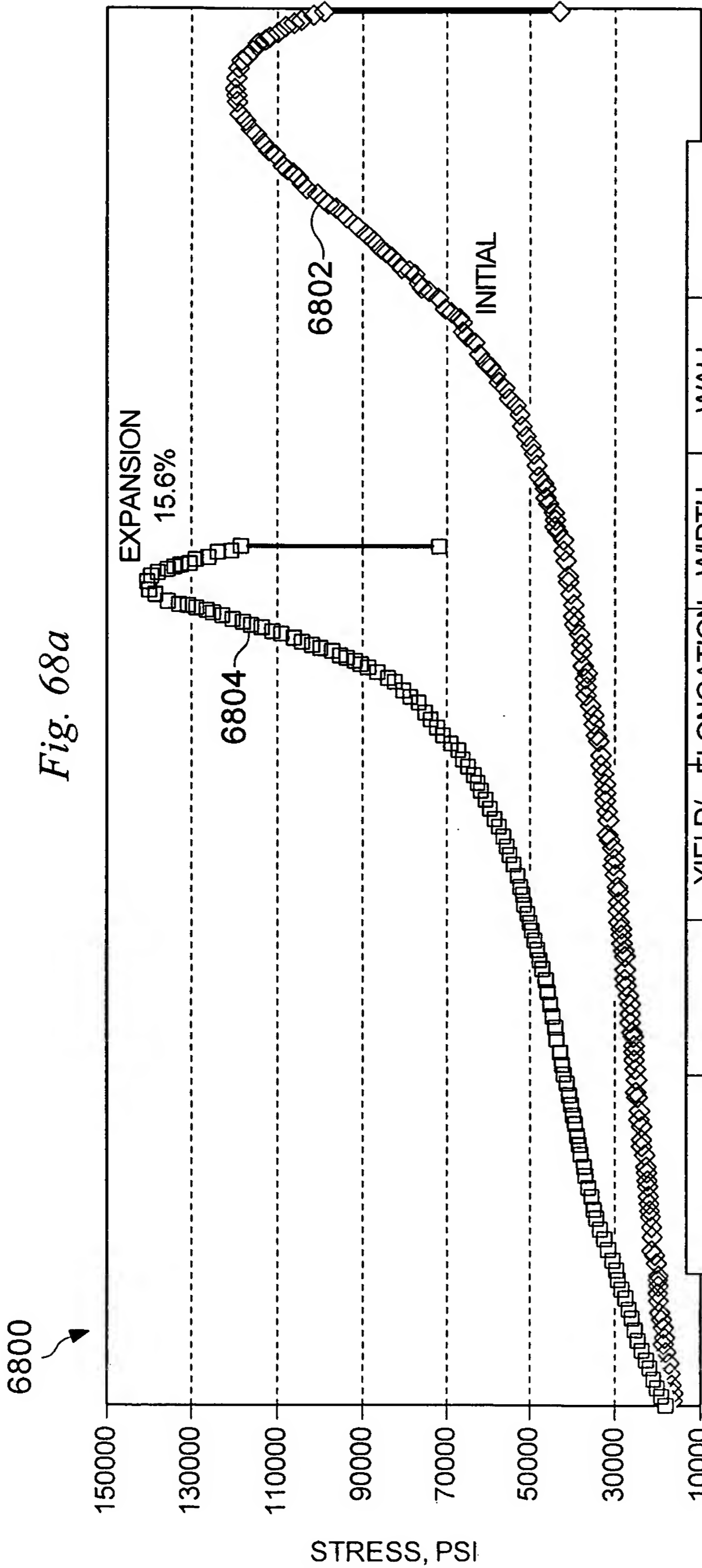
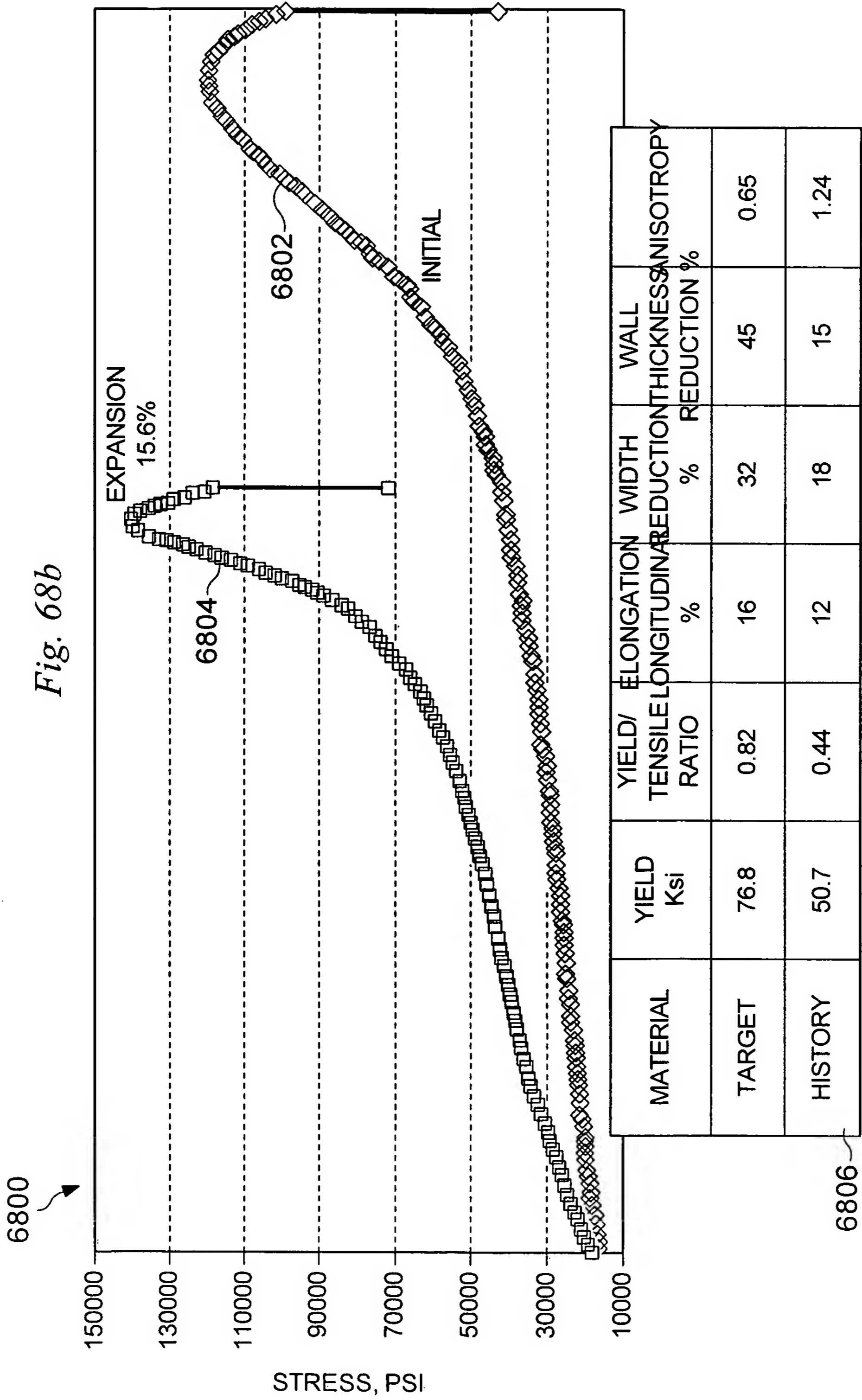


Fig. 68a

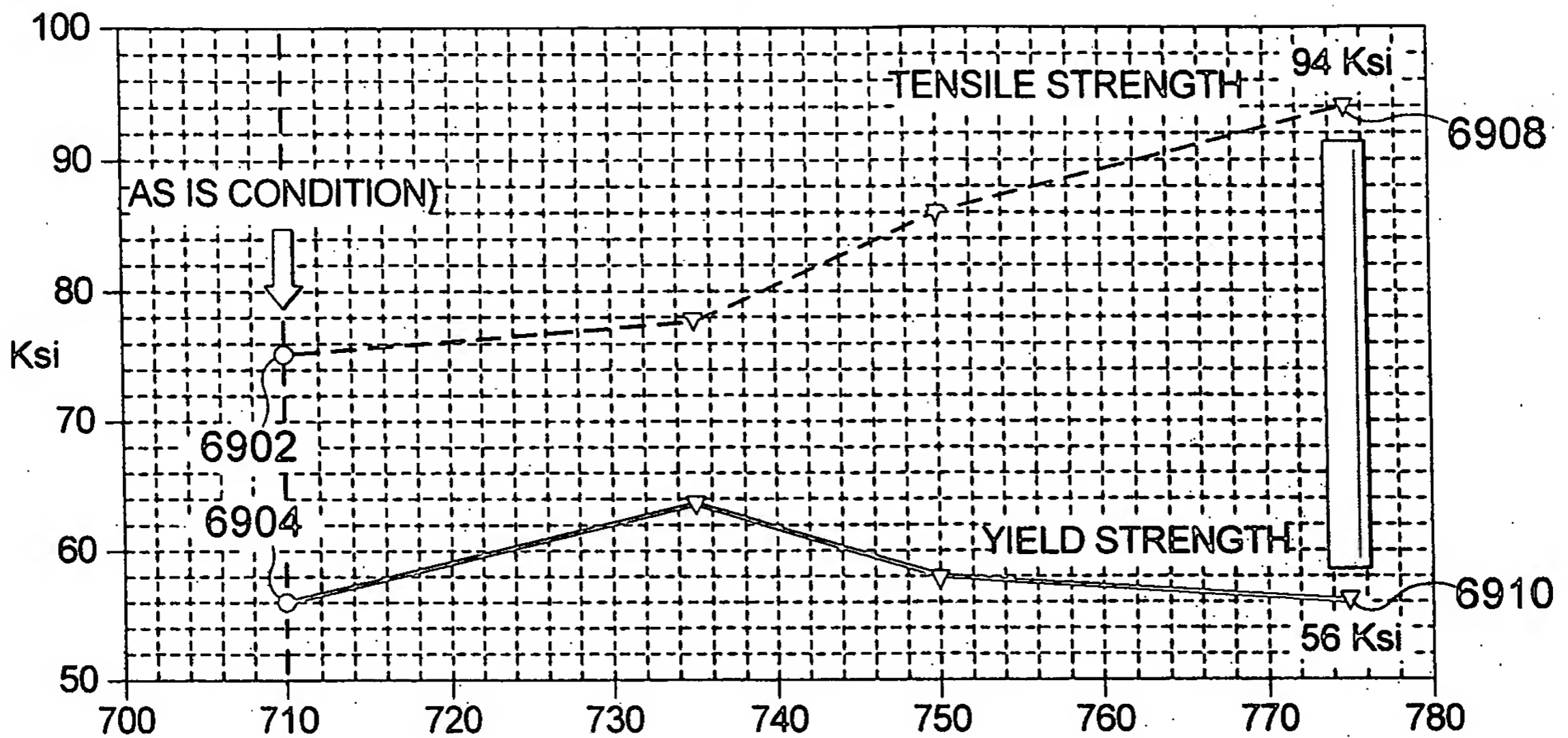
MATERIAL	YIELD Ksi	YIELD/ TENSILE RATIO	ELONGATION %	WIDTH REDUCTION %	WALL THICKNESS REDUCTION %	ANISOTROPY
TARGET	76.8	0.82	16	32	45	0.65
HISTORY	50.7	0.44	12	18	15	1.24



67/79

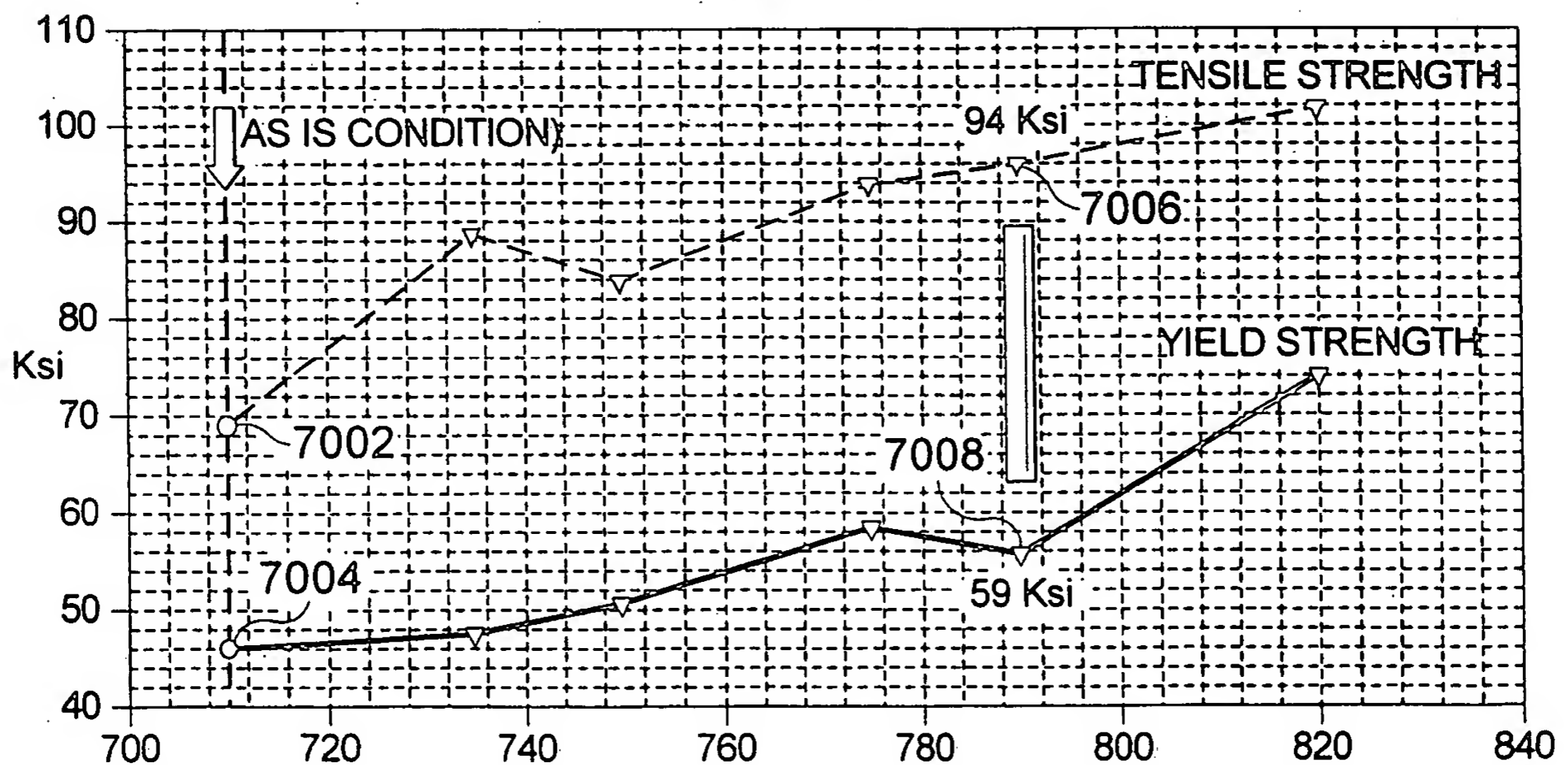
6900

Fig. 69



7000

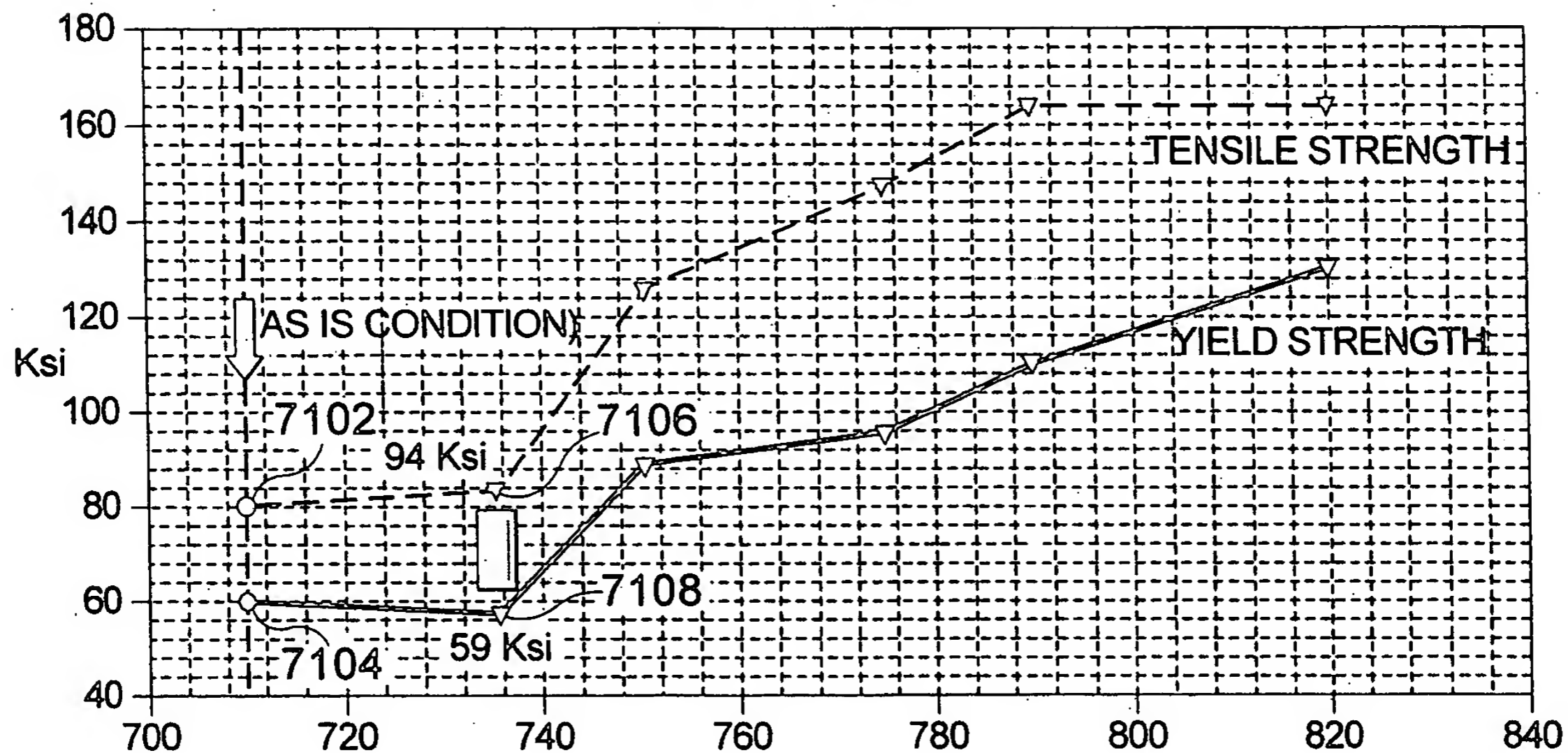
Fig. 70



68179

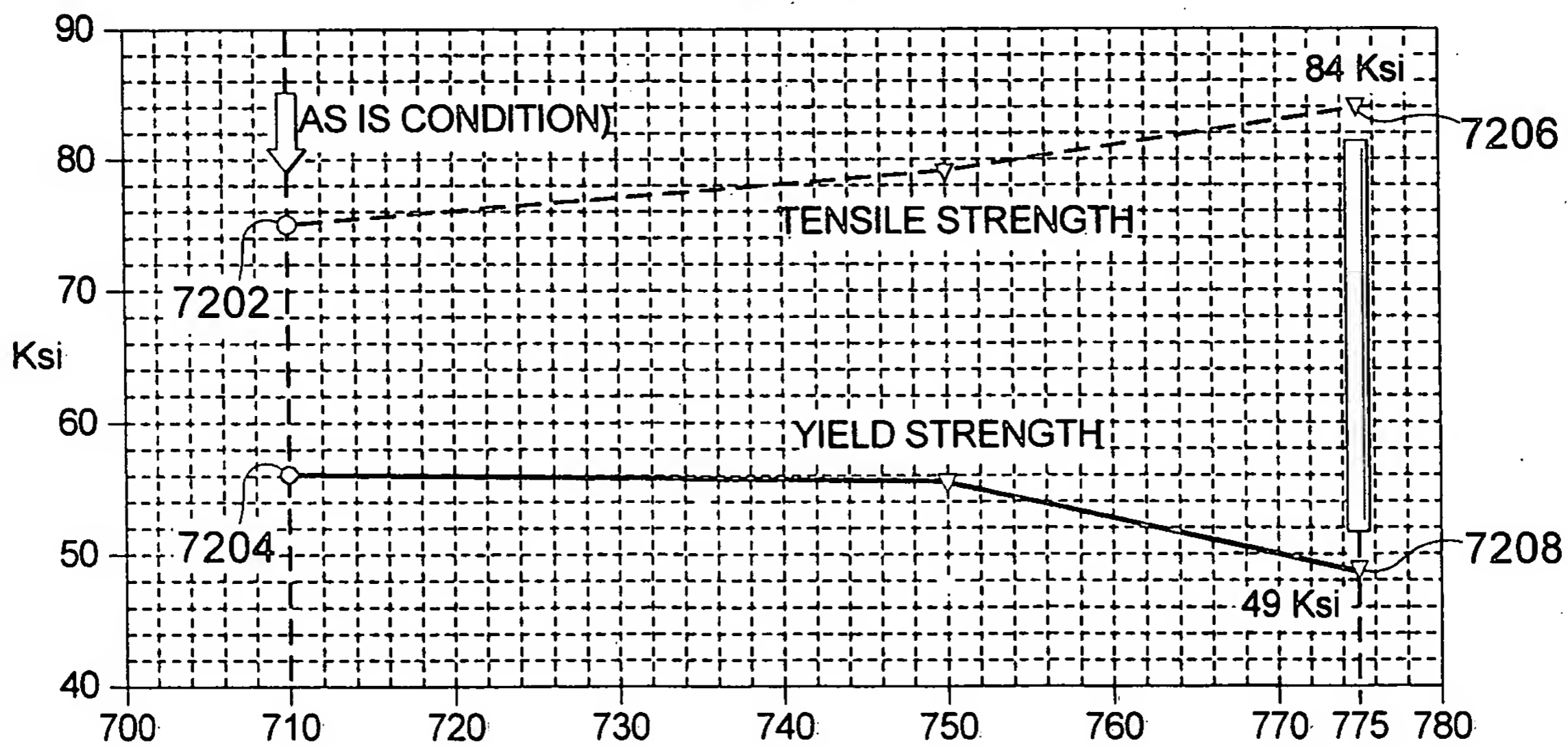
7100

Fig. 71



7200

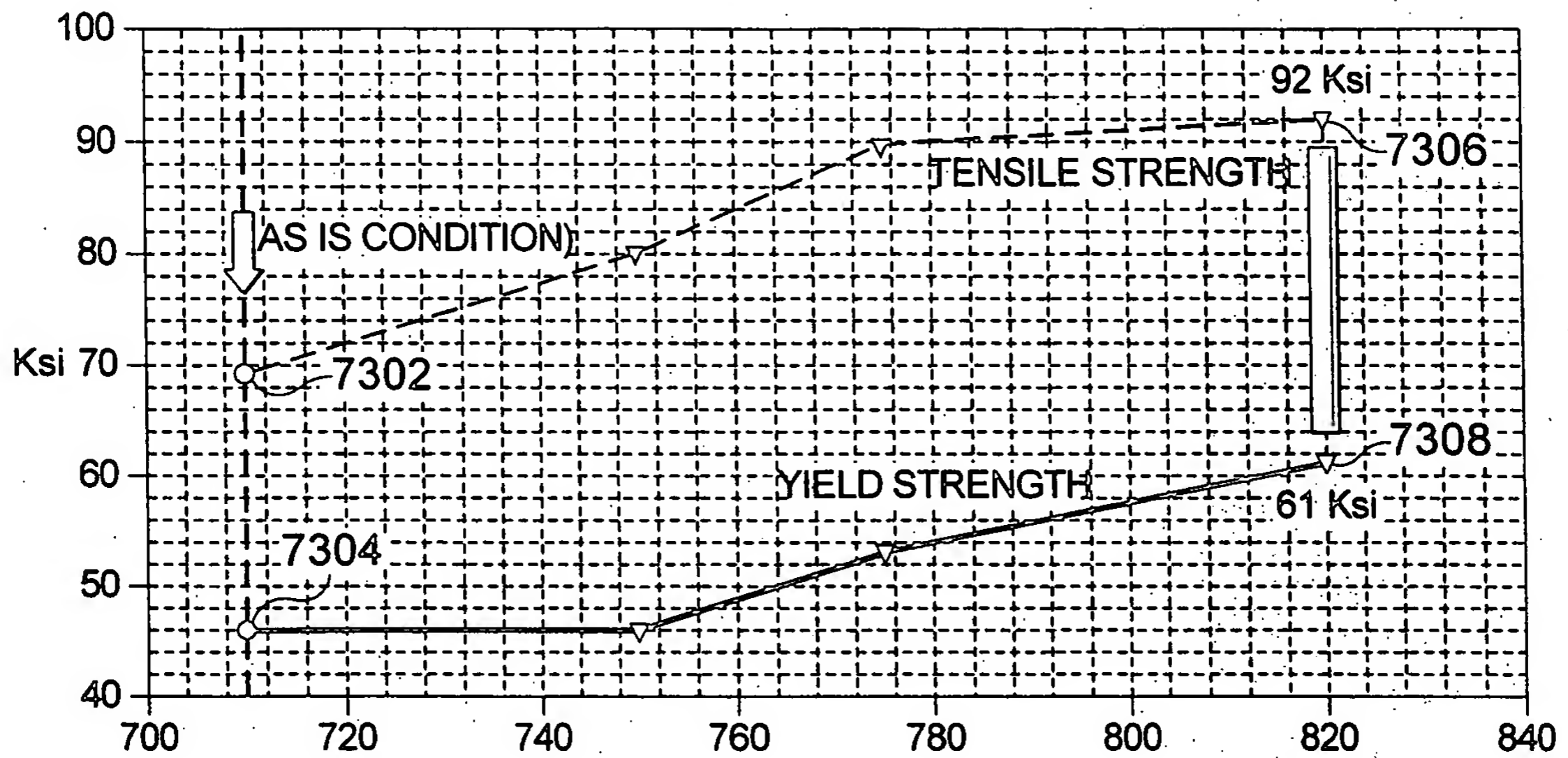
Fig. 72



69/79

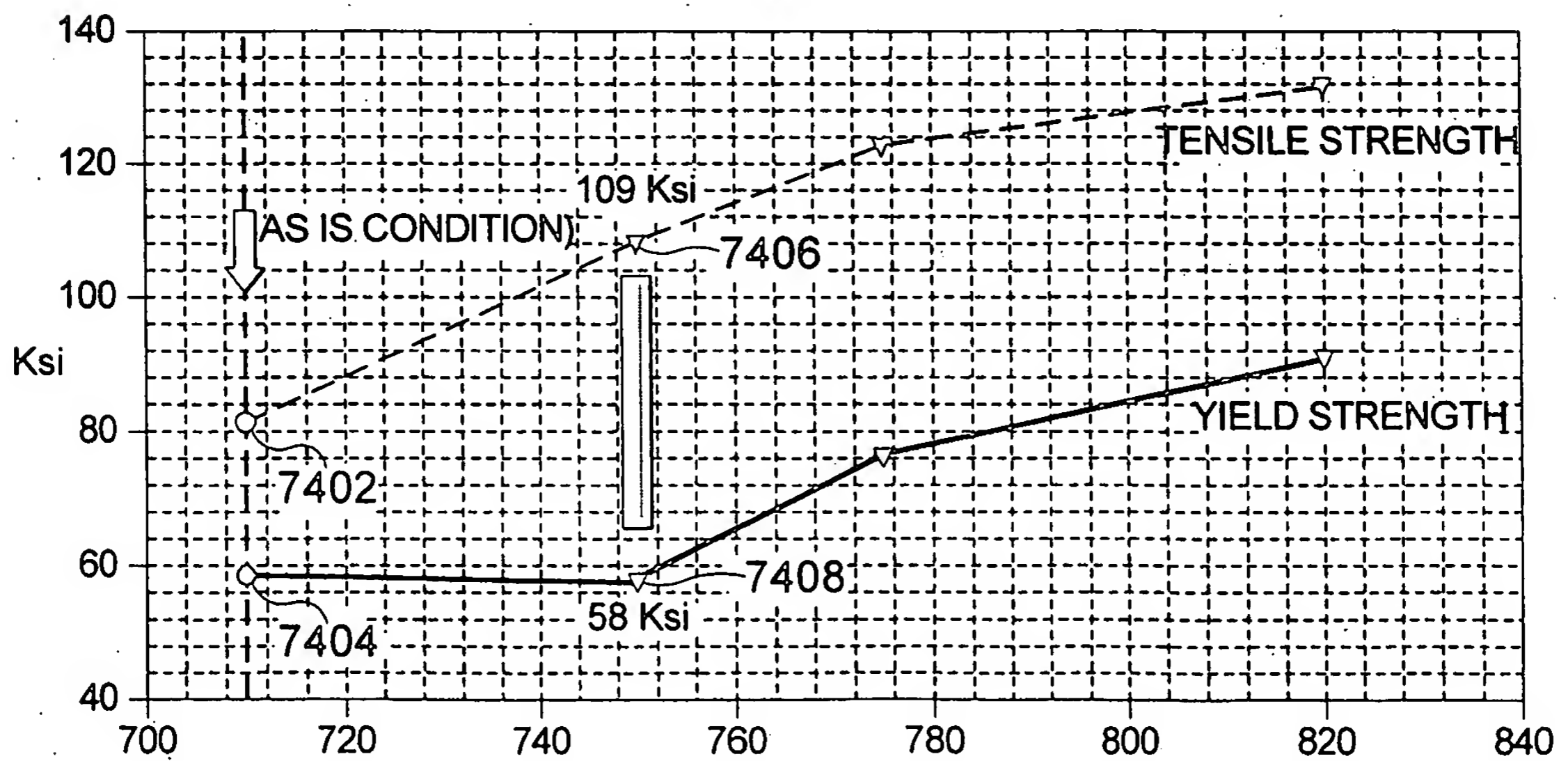
7300

Fig. 73



7400

Fig. 74



70/79

	7506	7508	7510	7512	7514	7516	
	MATERIAL	YIELD Ksi	YIELD/ TENSILE RATIO	ELONGATION LONGITUDINAL %	WIDTH REDUCTION %	WALL THICKNESS REDUCTION %	ANISOTROPY
7500	TARGET	80.18	0.857	14.75*	38.3	43.0	0.868
7502	QUENCH AND TEMPER PIPE-1	81.25	0.829	14.88*	37.8	43.25	0.830
7504	QUENCH AND TEMPER PIPE-2	78.77	0.822	15.90*	44.0	43.33	1.03

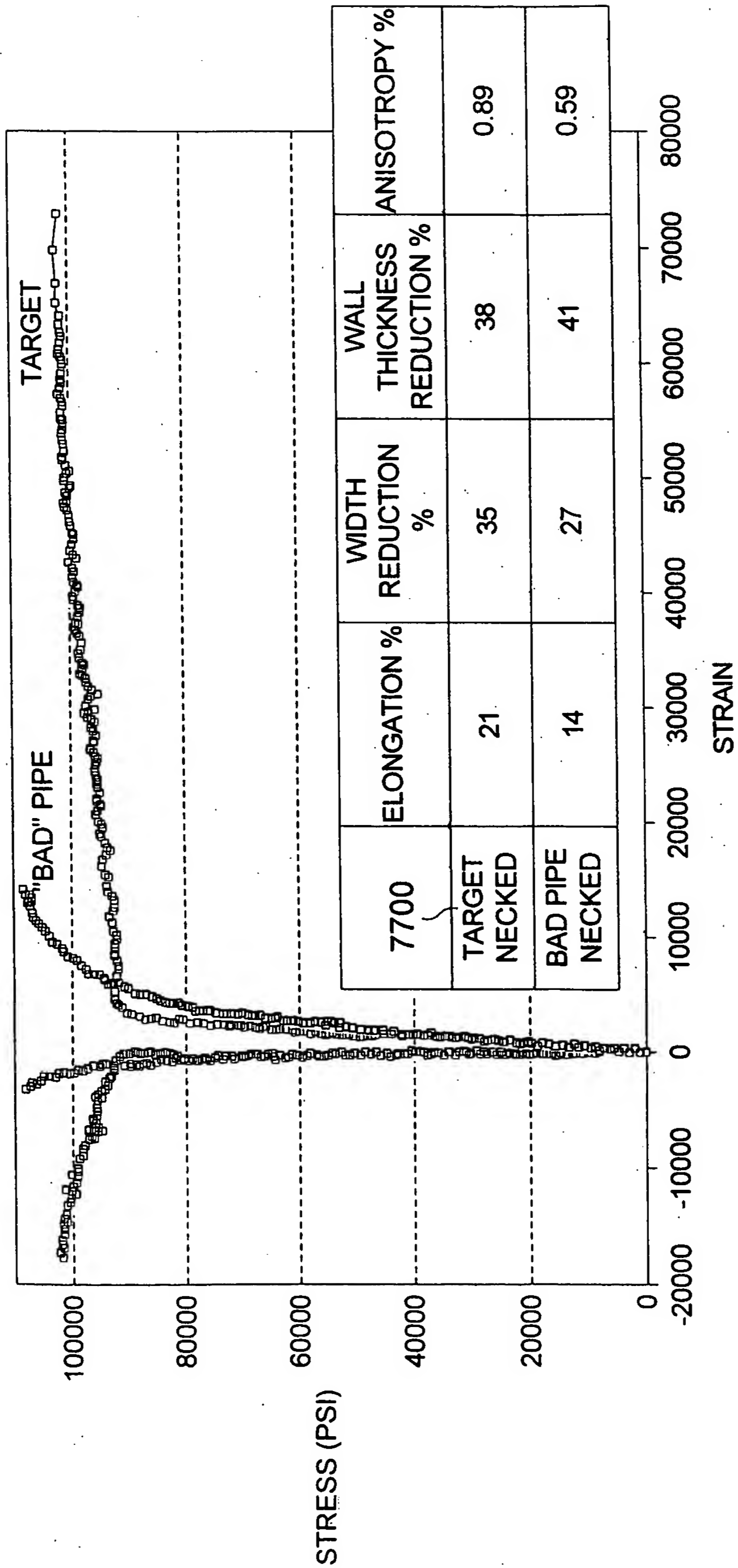
Fig. 75

	7504	7506	7508	7510	7512	7514	
	MATERIAL	YIELD Ksi	YIELD/ TENSILE RATIO	ELONGATION LONGITUDINAL %	WIDTH REDUCTION %	WALL THICKNESS REDUCTION %	ANISOTROPY
7500	TARGET	80.18	0.857	14.75*	38.3	43.0	0.868
7502	QUENCH AND TEMPER PIPE	80.19	0.826	15.25*	40.4	43.3	0.915

Fig. 76

71/79

Fig. 77a



72/79

Fig. 77b

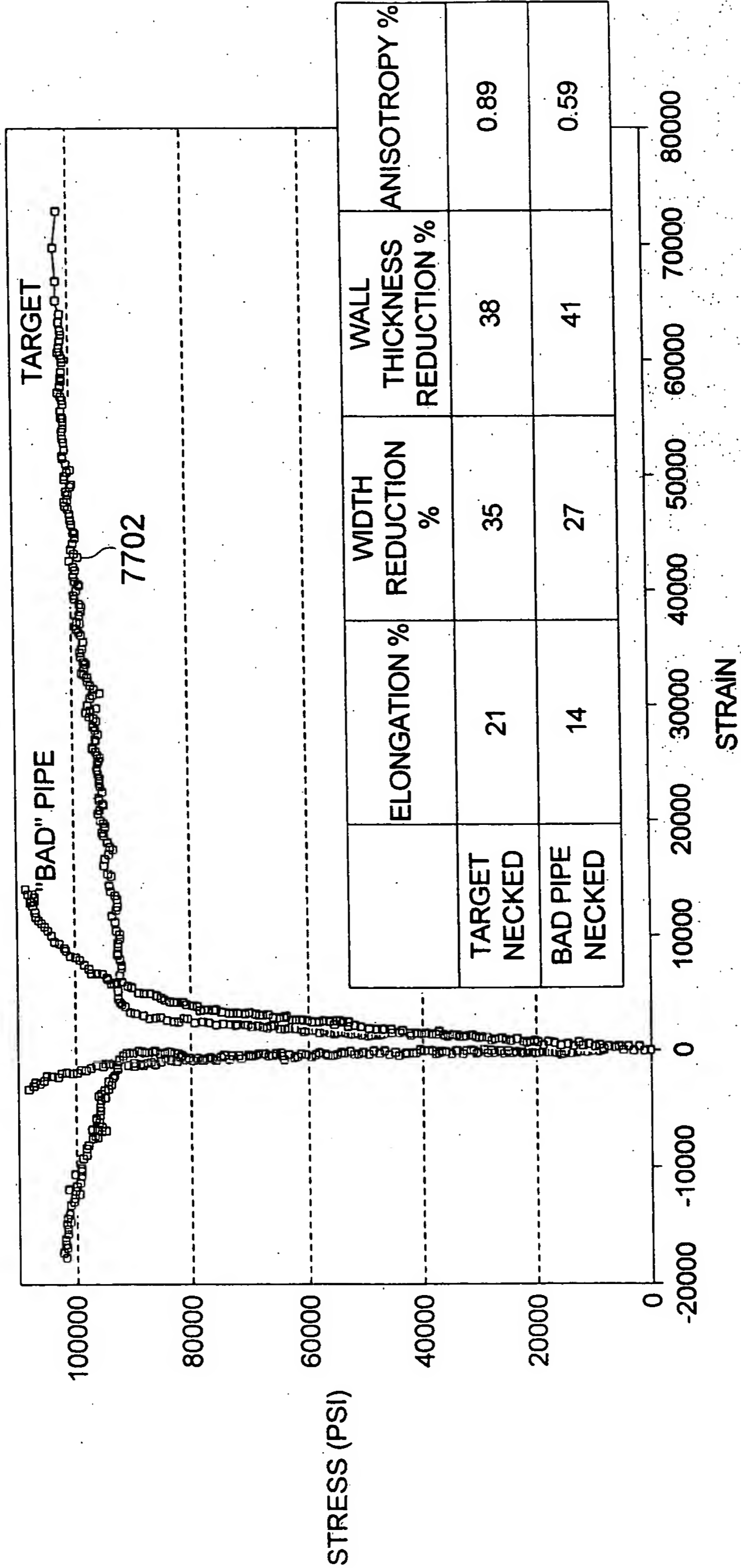


Fig. 78a

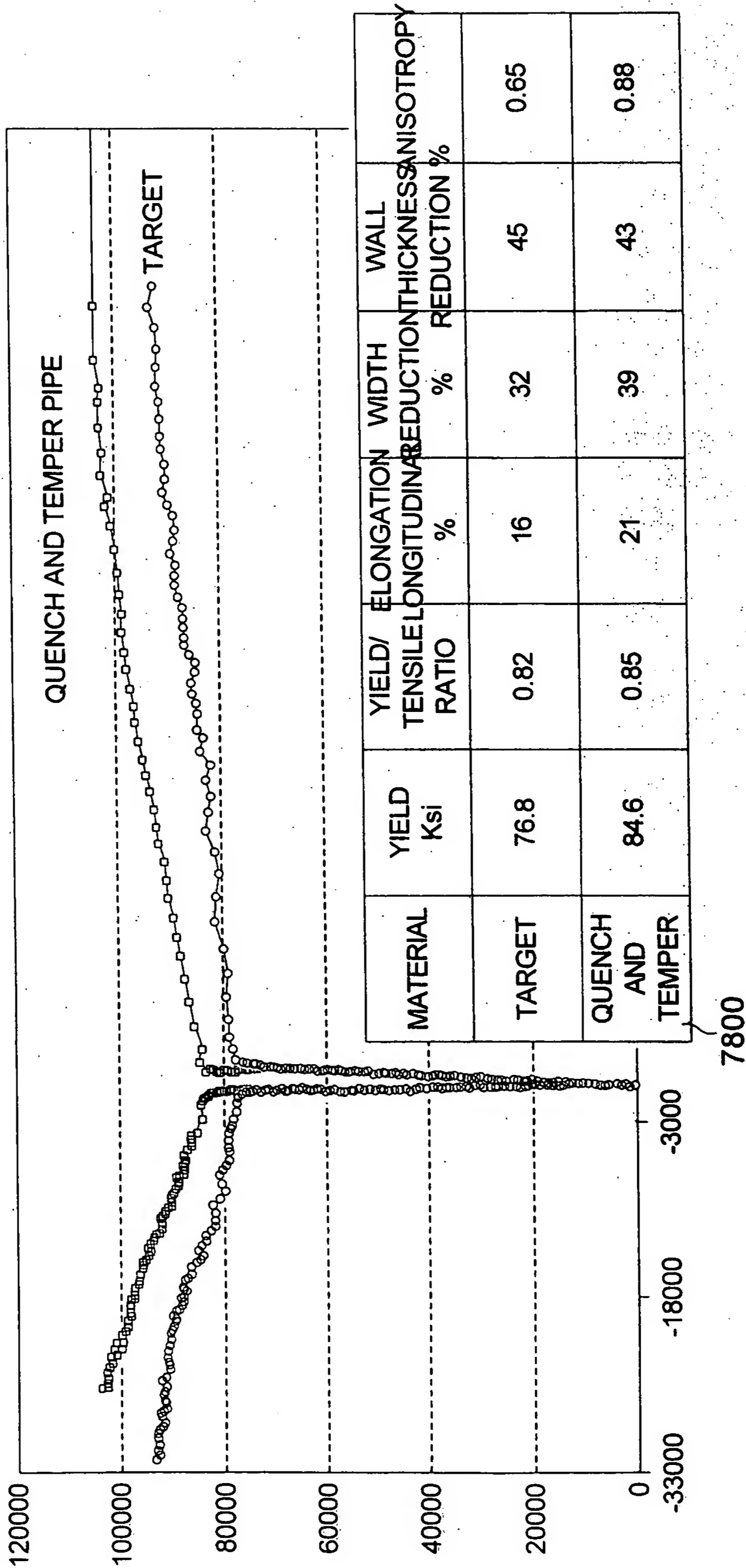


Fig. 78b

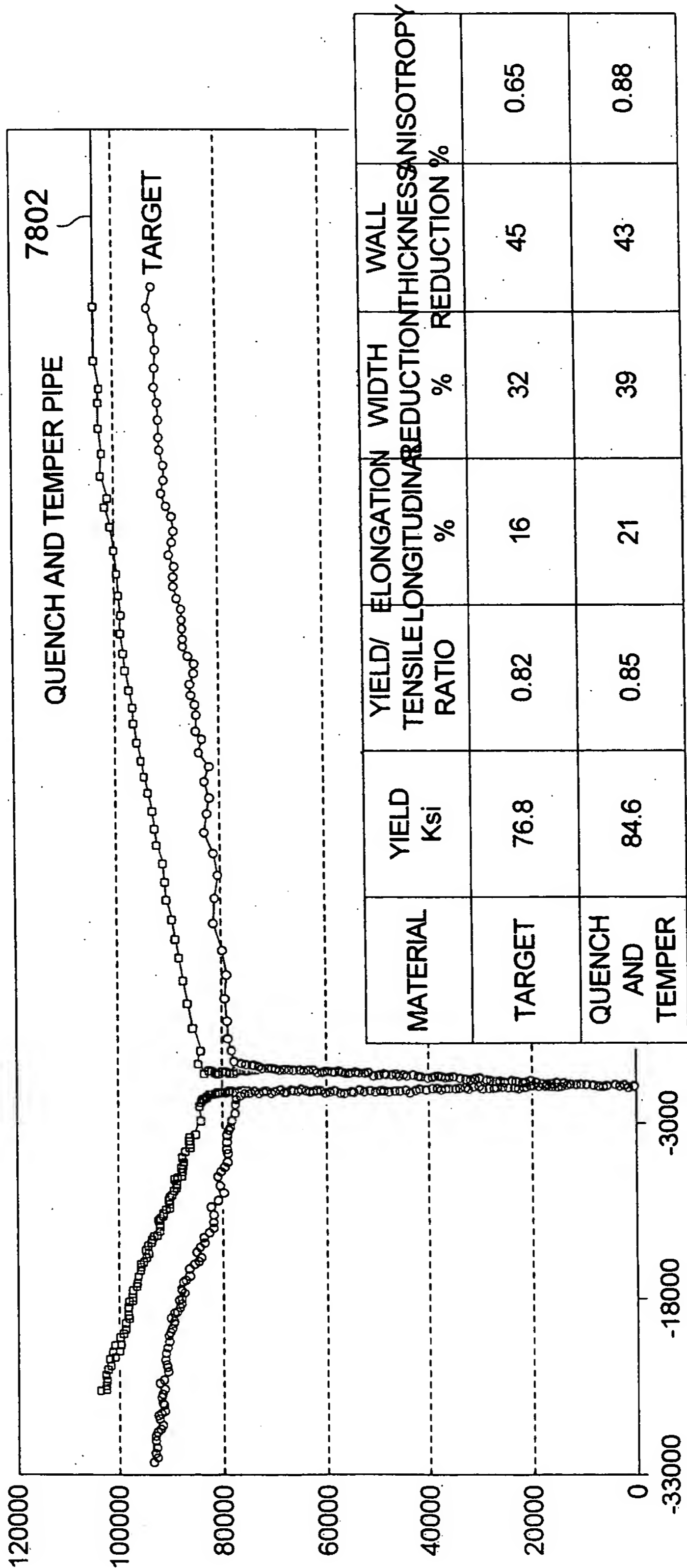


Fig. 79a

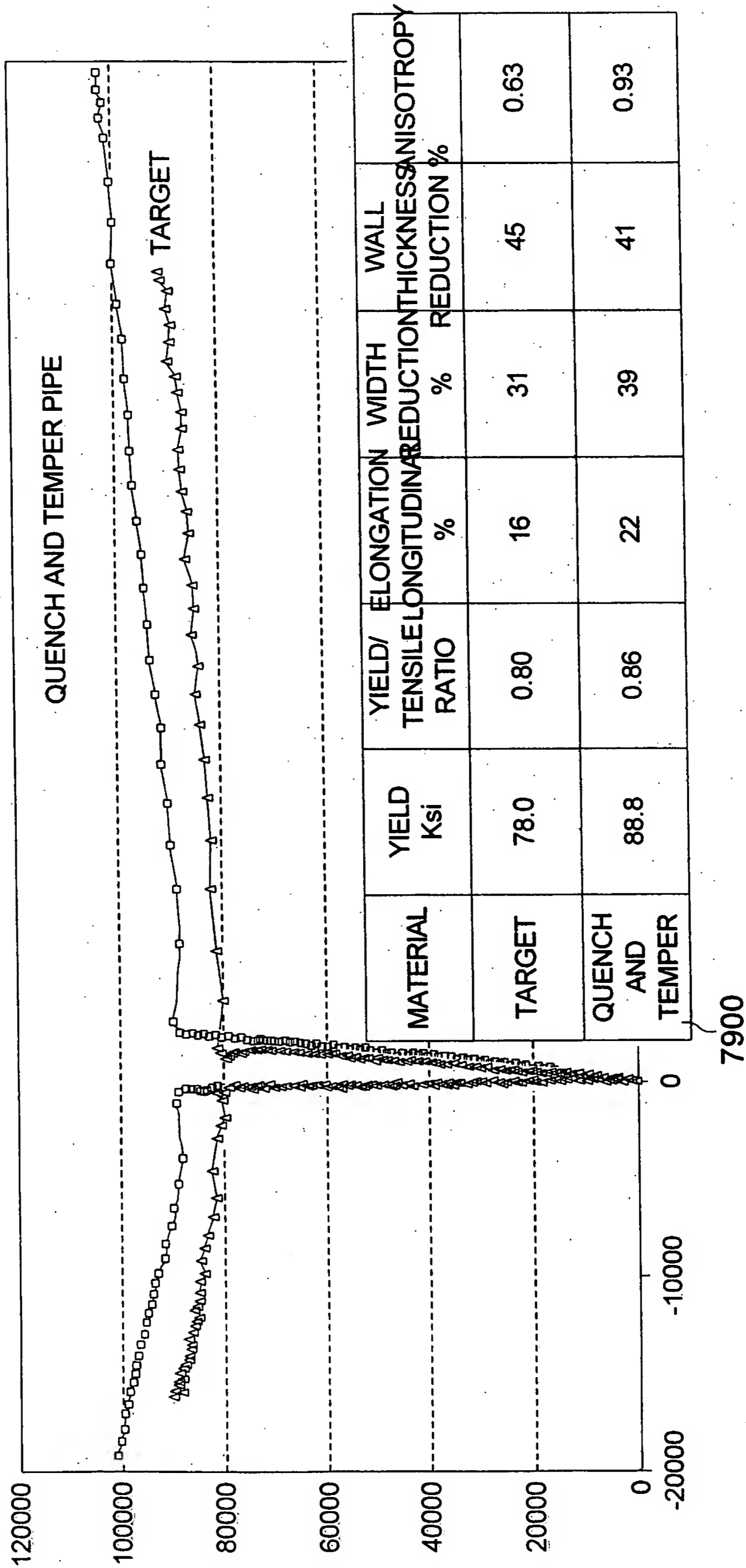


Fig. 79b

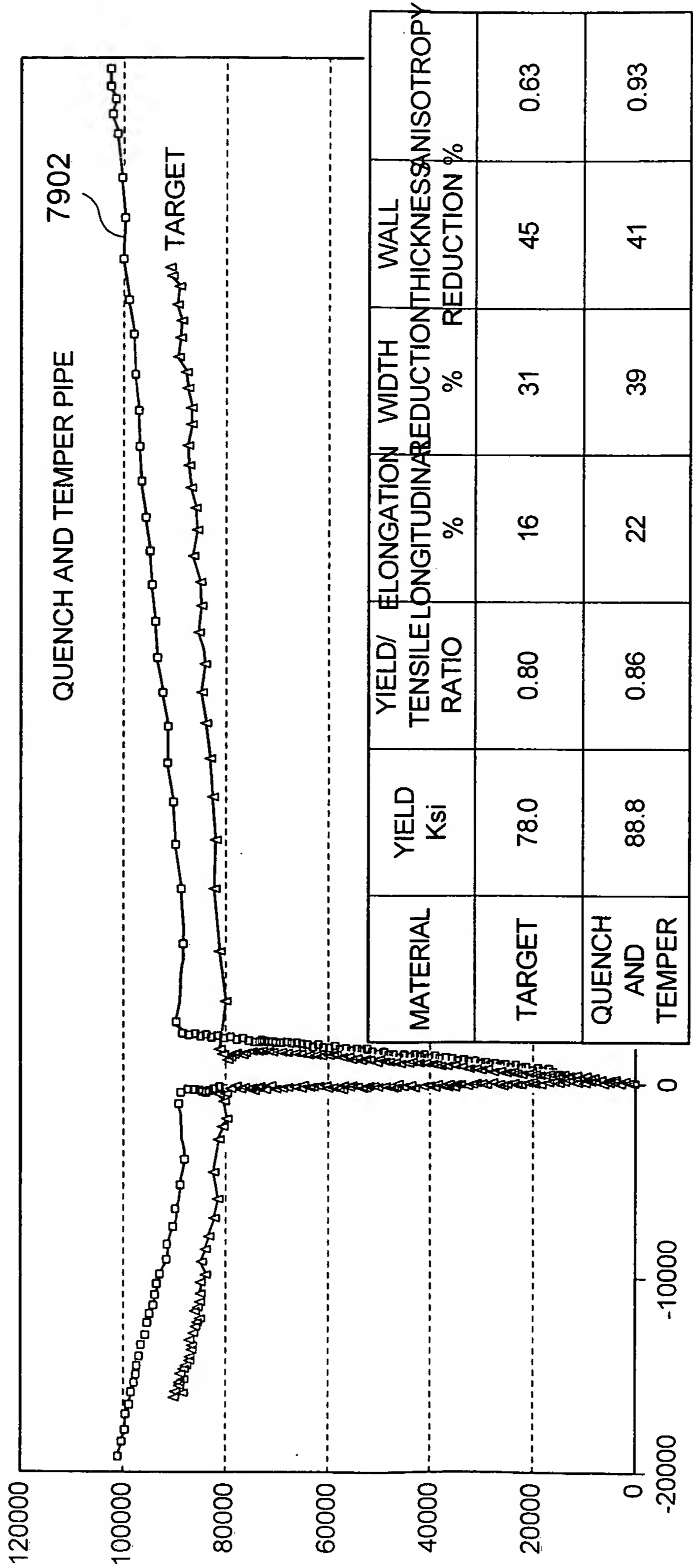


Fig. 80a

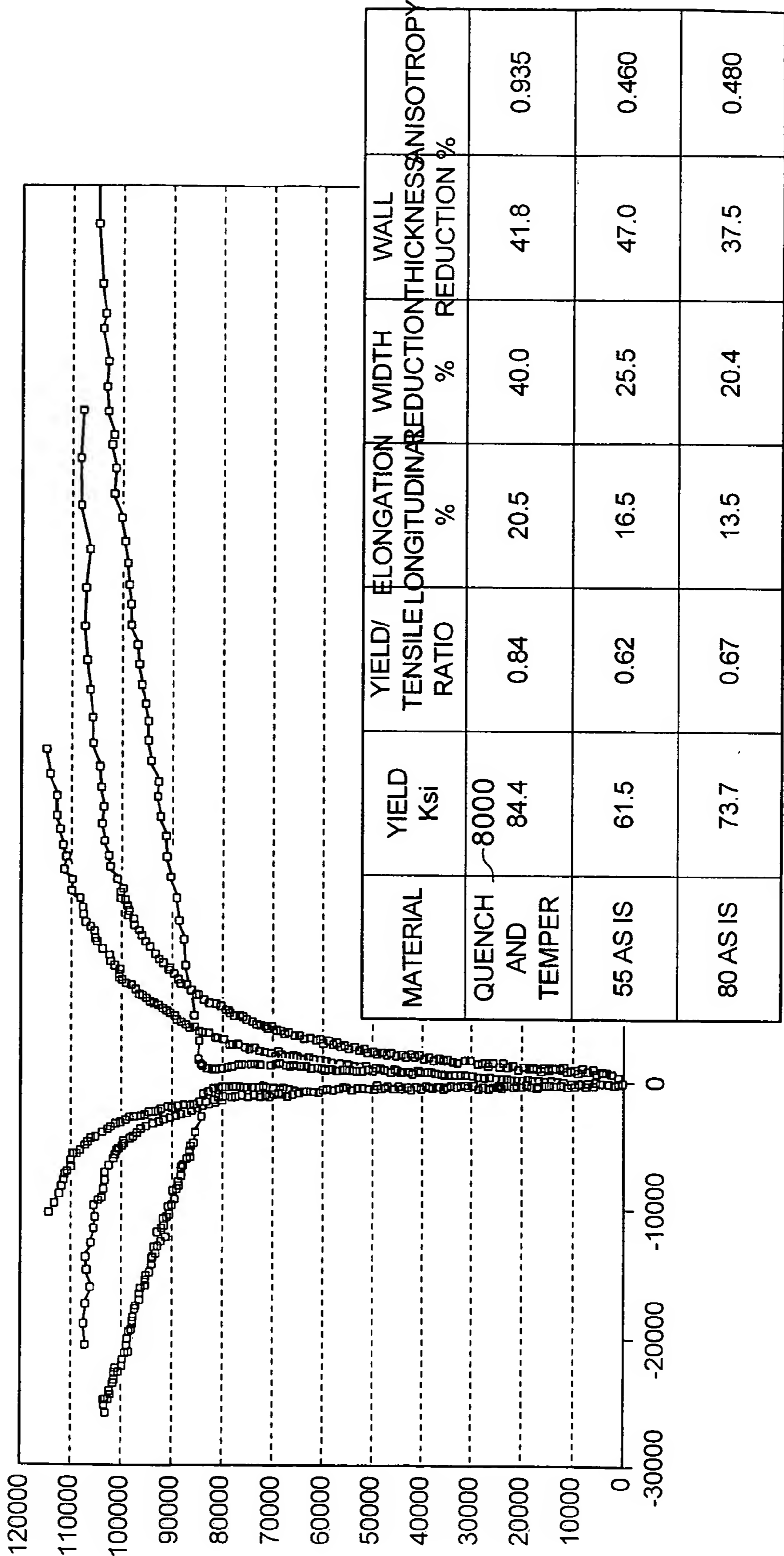


Fig. 80b

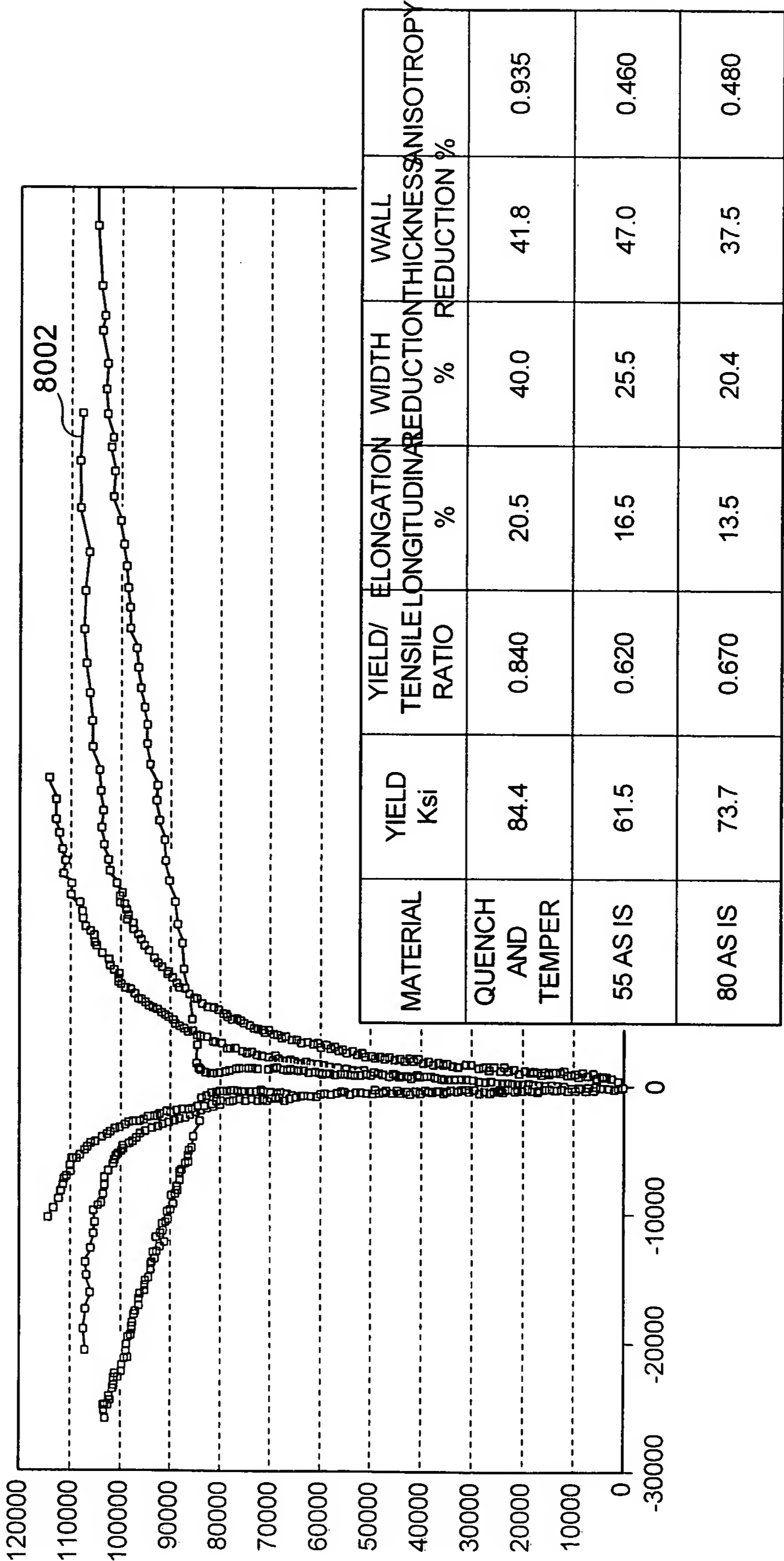


Fig. 81

SAMPLE	YIELD	Y/U	ELONGATION	WIDTH REDUCTION	WALL THICKNESS REDUCTION	ANISOTROPY	TECHNOLOGY
40045	80.1	.72	35	35	33	.92	HOT STRETCH, REDUCED (1950), ROTARY STRAIGHTENED
4-100	89.7	.88	25	22	20	1.1	NORMALIZED (1850), COLD DRAWN, ANNEALED (1050), ROTARY STRAIGHTENED
5-790	88.1	.87	16	24	30	.76	HOT STRETCH, REDUCED (1950) COLD DRAWN, ANNEALED, ROTARY STRAIGHTENED
40513	47.7	.73	38	43	49	.83	HOT STRETCH, REDUCED (1850), ROTARY STRAIGHTENED
40514	45.5	.69	40	50	53	.93	HOT REDUCED (1850), COLD SIZED, ROTARY STRAIGHTENED
40241	52.7	.85	49	49	46	1.1	HOT STRETCH, REDUCED (1850), ROTARY STRAIGHTENED

8100
8102
8104
8106
8108
8110

Fig. 82

MATERIAL	ABSORBED ENERGY^A LONGITUDINAL TRANSVERSE WELD			FLARE EXPANSION %
TARGET	80	60	60	45
QUENCH AND TEMPER	125	59	176	42
QUENCH AND TEMPER	145	59	174	52
AS IS, 55 GRADE	100	40	70	32*
AS IS, 80 GRADE	50	30	4	30*

8200
8202

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